Nutrient-Pathogen Evaluation Program for On-Site Wastewater Treatment Systems

Idaho Department of Environmental Quality

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1.0 Authority

The Idaho Department of Environmental Quality (DEQ) has been charged with protecting human health and the environment per the *Environmental Protection and Health Act* (EPHA) Idaho Code §§ 39-101 through 130. The EPHA also more specifically provides that it is the policy of the state to maintain the existing high quality of the state's ground water and to prevent ground water contamination to the maximum extent practical. Idaho Code § 39-102(2) and (3). Under the authority granted DEQ in the EPHA, and in accordance with the *Idaho Administrative Procedures Act* (Idaho Code §§ 67-5201 through 5292), DEQ has adopted rules and generated guidance. The *Ground Water Quality Rule* (IDAPA 58.01.11), the *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02), the *Individual/Subsurface Sewage Disposal Rules* (IDAPA 58.01.03), and this guidance, the *Nutrient-Pathogen Evaluation Program for On-Site Wastewater Treatment Systems*, are some of the rules and guidance that have been developed to execute DEQ's mandate to protect human health and the environment.

Idaho Code § 39-414 provides for the delegation of authority regarding environmental programs from DEQ to the Public Health Districts (PHDs). Pursuant to this statutory provision, DEQ has delegated authority to the PHDs through the execution of a *Memorandum of Understanding.* (The *Memorandum of Understanding* (MOU) can be found at http://www.deq.state.id.us/rules/mous/deq_phds.pdf.) It is through the cooperation of the PHDs and the use of the Nutrient-Pathogen Evaluation guidance that DEQ, developers, consultants, and the general public attempt to prevent contamination of the ground water through subsurface discharge of wastewater.

2.0 Nutrient – Pathogen Evaluation Objectives

An N-P evaluation must demonstrate that the proposed on-site wastewater treatment system(s) will not degrade ground water or surface water quality beyond existing levels and will not exceed applicable ground water quality standards.

N-P evaluations are designed to accomplish both of the following:

1. Designate an appropriate number of on-site wastewater treatment systems on a given parcel of land.
2. Direct the placement of the individual on-site wastewater treatment systems in a way that will not degrade the quality of ground water or surface water resources.

These objectives are consistent with the EPHA and the Ground Water Quality Rule (see IDAPA 58.01.11).

3.0 General Requirements

This document provides guidance for developers, contractors, and consultants in performing *Nutrient-Pathogen* (N-P) Evaluations, either under a district health department's *Land Development Program* or DEQ's oversight of *central systems* (CS)[1] and *large soil absorption systems* (LSAS).[2]

3.1 Qualifications for Performing N-P Evaluations

A qualified professional with experience in subsurface resource evaluation should perform N-P evaluations. Environmental consultants with training and experience in geology, hydrogeology, soil science, geochemistry, or related engineering disciplines typically have these qualifications.

The evaluation should relate the predicted nutrient and pathogen movement in the subsurface to the type of on-site wastewater treatment system proposed while taking into consideration the soil horizon, geologic, and hydrologic conditions existing at the site, and the surrounding current and future land uses. The professional performing the evaluation must certify that the results and any recommendations on design or placement of on-site wastewater treatment systems satisfy the N-P Evaluation approval criteria.

3.2 Applicable Rules and Guidance

A permit is required for the modification, repair or construction of any individual or subsurface sewage disposal system in Idaho. Individual/Subsurface Disposal Rules (SSD rules), IDAPA 58.01.03.005.01.(See also the associated *Technical Guidance Manual for Individual and Subsurface Sewage Disposal Systems* (TGM)). The TGM can be obtained from the DEQ Web site:

http://www.deq.state.id.us/water/assist_business/septic/tech_manual_updates.cfm) These permits are issued by the PHDs. The systems requiring permits include individual systems, central systems (CS) and large soil absorption systems (LSAS). A permit can only be issued if the proposed system will meet all applicable rules, and will not interfere or injure existing or potential beneficial uses of the waters of the state. IDAPA 58.01.03.005.05; 58.01.03.003.13; 58.01.03.004.01.

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1 The *Individual/Subsurface Sewage Disposal Rules* (IDAPA58.01.03) define a CS as "Any system which receives blackwaste or wastewater in volumes exceeding twenty-five hundred (2,500) gallons per day; any system which receives blackwaste or wastewater from more than two (2) dwelling units or more than two (2) buildings under separate ownership."(IDAPA 58.01.03.003.08)

2 The *Individual/Subsurface Sewage Disposal Rules* (IDAPA 58.01.03) define an LSAS as "a subsurface sewage disposal system designed to receive two thousand five hundred (2,500) gallons of wastewater or more per day, including where the total wastewater flow from the entire proposed project exceeds two thousand five hundred (2,500) gallons per day but the flow is separated into absorption modules which receive less than two thousand five hundred (2,500) gallons per day." (IDAPA 58.01.03.003.20)

The Ground Water Quality Rule is one of the applicable rules referenced in the SSD Rules. The Ground Water Quality Rule serves as the basis for the administration of programs which address ground water quality. IDAPA 58.01.11.001.02. The Rule directs DEQ to use the numeric and narrative standards in the Rule as a basis for identifying permit conditions, such as the conditions required in a SSD permit. Section 301 of the Ground Water Quality Rule requires that all activities with the potential to degrade general resource waters in the state must be managed in a manner which maintains or improves existing ground water quality through the use of best management practices and best practical methods to the maximum extent practical. The existing ground water quality is not maintained, or is degraded, when the lowering of ground water quality can be measured in a statistically significant and reproducible manner. IDAPA 58.01.11.007.13 (definition of "degradation"). The Ground Water Quality rule also includes numerical limits for certain pollutants. IDAPA 58.01.11.200.

Idaho's Wastewater Rules, IDAPA 58.01.16, are also applicable rules under the SSD permit process. The Wastewater Rules provide, in section 260, that subsurface sewage or wastewater disposal facilities must be designed and located so that pollutants cannot be reasonably expected to enter water of the state in concentrations resulting in injury to beneficial uses.

In order to obtain a SSD permit, the applicant must submit a permit application. The application must contain the information necessary for PHD or DEQ to make a determination whether the proposed system meets applicable rules, including the Ground Water Quality Rule, and will not interfere or injure beneficial uses of the waters of the state. The application must include a soil description and profile, ground water data, percolation or permeability test results and/or a site evaluation report. IDAPA 58.01.03.005.i. The agency may also require in the application any other information that may be necessary to substantiate that the proposed system will comply with applicable rules. IDAPA 58.01.03.005.o. Under these rules then, DEQ or the PHDs may require as part of the application site specific information and an evaluation of the site of the proposed system, including a N-P evaluation, to determine whether a permit should be issued.

The SSD Rules also specifically provide that a site investigation may be required before a permit for a large soil absorption system may be permitted. Such an investigation is to be conducted by a soil scientist and/or hydrogeologist and must conclude that the effluent will not adversely impact or harm the waters of the state. IDAPA 58.01.03.013.01.

The Engineer of Record (EoR) shall complete the N-P evaluation. The evaluation must show that the proposed subsurface wastewater disposal will not interfere or injure or adversely impact beneficial uses of waters of the state and will meet applicable rules, including the Ground Water Quality Rule. The Ground Water Quality Rule requires that existing ground water quality be maintained (not degraded) or improved through the use of best management practices and best practical methods to the maximum extent practical.

3.3 Nutrient-Pathogen Evaluation requirements

N-P evaluations must include a comprehensive, scientifically based investigation of soils, geologic conditions, and water resources in and around the area of the proposed development, CS, or LSAS. For approval of an on-site wastewater treatment system, the N-P evaluation must demonstrate that the effluent from the treatment system(s) will not interfere or injure or adversely impact beneficial uses of waters of the state and will not lower or degrade existing ground water quality. The degradation of existing ground water quality is indicated as any statistically significant increase in a ground water contaminant as defined in the *Ground Water Quality Rule* (IDAPA 58.01.11).

DEQ requires N-P evaluations for all LSAS and those CS that are located in areas of "sensitive resource" aquifers (e.g., Spokane Valley-Rathdrum Prairie aquifer) as described in Idaho's Ground Water Quality Rule (IDAPA 58.01.11.300.01.a.i). *Areas of concern*—consisting of, but not necessarily limited to, areas with locally degraded aquifers, shallow aquifers, or thin soils over bedrock—may also be required to complete and submit an N-P Evaluation for review.

Examples of an area of concern are the many *Nitrate Priority* areas located throughout the state, where the local aquifer has elevated levels of anthropogenic nitrates. Figure 3 – 1 shows a map of the ranked nitrate priority areas. Nitrate priority areas are ranked in decreasing order of ground water quality degradation due to nitrate contamination. Nitrate priority area designations are based on a compilation of the available ground water quality data in Idaho and were set by the state's *Ground Water Monitoring Technical Committee*.

Additionally, DEQ requires that a N-P Evaluation be performed for any permit proposing the use of Seepage Pits. Due to the Point-Source nature of Seepage Pits, which allows for an Application Rate exceeding that tabulated in the Individual/Subsurface Sewage Disposal Rules (IDAPA 58.01.03.008.03.b), the potential impact on the aquifer must be evaluated to secure the existing and future beneficial use of waters of the state.

3.3.1 Site Investigation requirements

On-site soils investigations must be made at potential subsurface wastewater dispersal sites. The soil description should be made by a soil scientist, preferably a Certified Professional Soil Scientist (CPSS). The soil description should include information sufficient to determine the suitability of the soil to adequately treat wastewater with the anticipated characteristics and application rates. The wastewater characteristics will dictate the kinds of soil attributes that will be required. It is useful to have the soil classified according to *soil taxonomy* (USDA-SCS, 1984).

Typically, the description should include: texture of different horizons, estimated organic matter of the subsurface horizons, horizon thickness, color, structure and pH. The soil's nutrient status, including plant available nitrogen and phosphorus, is also critical to quantify if root zone dispersal (Drip Distribution System) is to be considered as a viable subsurface dispersal configuration. Other factors include depth and characteristics of the underlying bedrock or limiting layer, natural soil drainage, permeability of the least permeable layer, depth to seasonal water table, and soil slopes. Descriptions of other soil characteristics may be needed, such as infiltration rate, Cation Exchange Capacity (CEC), type and quantity of clay, Available Water Capacity (AWC), type and percentage of coarse fragments, soil temperature and moisture regimes, salinity, Sodium Adsorption Ratio (SAR), flooding potential, coatings of oxides, sesquioxides, and zones of carbonate accumulation.

The relative importance of each of these soil attributes will depend on the wastewater characteristics, in addition to the soil matrix constituents. The soil's solid matrix consists of sand, silt, clay and organic matter. Because of their small relative surface area, the sand and silt elements are essentially nonreative. These soil textures provide a relatively rigid framework containing the clay and organic matter but by themselves function largely as a physical filter. On the other hand, the clays and organic elements are extremely reative, thus determining the soil's efficacy for treating the applied wastewater. These considerations will help determine the limiting factors associated with the proposed site and the sites compatability with the proposed wastewater treatment technology.

3.3.2 Wastewater Attributes

Subsurface wastewater disposal requires that the wastewater meet, at a minimum, the domestic wastewater constituent criteria published on page 20-1 of the TGM, Table 08. Any proposal for subsurface disposal of wastewater's not meeting these criteria must be processed such that these criteria are met at a minimum. DEQ has developed and provides a Non-Domestic Wastewater Check Sheet to assist in evaluation of these noncompliant wastewaters.

Every effort should be made to apply wastewater at a rate and in a manner that will minimize leaching of nutrients and pathogens to the aquifer, thereby assuring existing and future aquifer beneficial uses. Acceptable application rates are specified in Table 7 of the TGM, page 14. Advanced treatment may provide additional flexibility due to reduced nutrient loading. Qualifying advanced treatment technologies may include Extended Treatment Package Systems (ETPS), Recirculating Gravel Filters (RGF), Intermittent Sand Filters (ISF), and the Sand Mound. If the selected system qualifies, the enhanced application rate table, located in the TGM's Intermittent Sand Filter section may be used.

3.3.3 Surrounding Land Use & Associated Aquifer Beneficial Uses

An evaluation of the surrounding land uses must take place as part of determining the site acceptability for subsurface wastewater application. The present land use should be evaluated during site selection. The planned use of the site should not conflict with the present or planned uses of adjacent property. Land uses that need to be considered in site evaluation include proximity to municipal and domestic wells, proximity of homes, proximity of property lines, proximity of surface waters, and stormwater features. It may not be suitable for a subsurface wastewater application site to be located up gradient of a municipal or domestic drinking water well. Ground water supplies the drinking water to approximately 95% of Idaho's population. The N-P Evaluation will assist in securing that this beneficial use will be able to continue unhindered, thereby saving public and private water users, developers and engineers potentially expensive litigation, and/or the expense of drilling replacement wells, if an uninfluenced source can be found. All water wells, monitoring wells, low termperature geothermal wells, injection wells and other artificial openings and excavations which are deeper than 18 feet are required to obtain a well drilling permit from the Idaho Department of Water Resources (IDWR) (IDAPA 37.03.09).

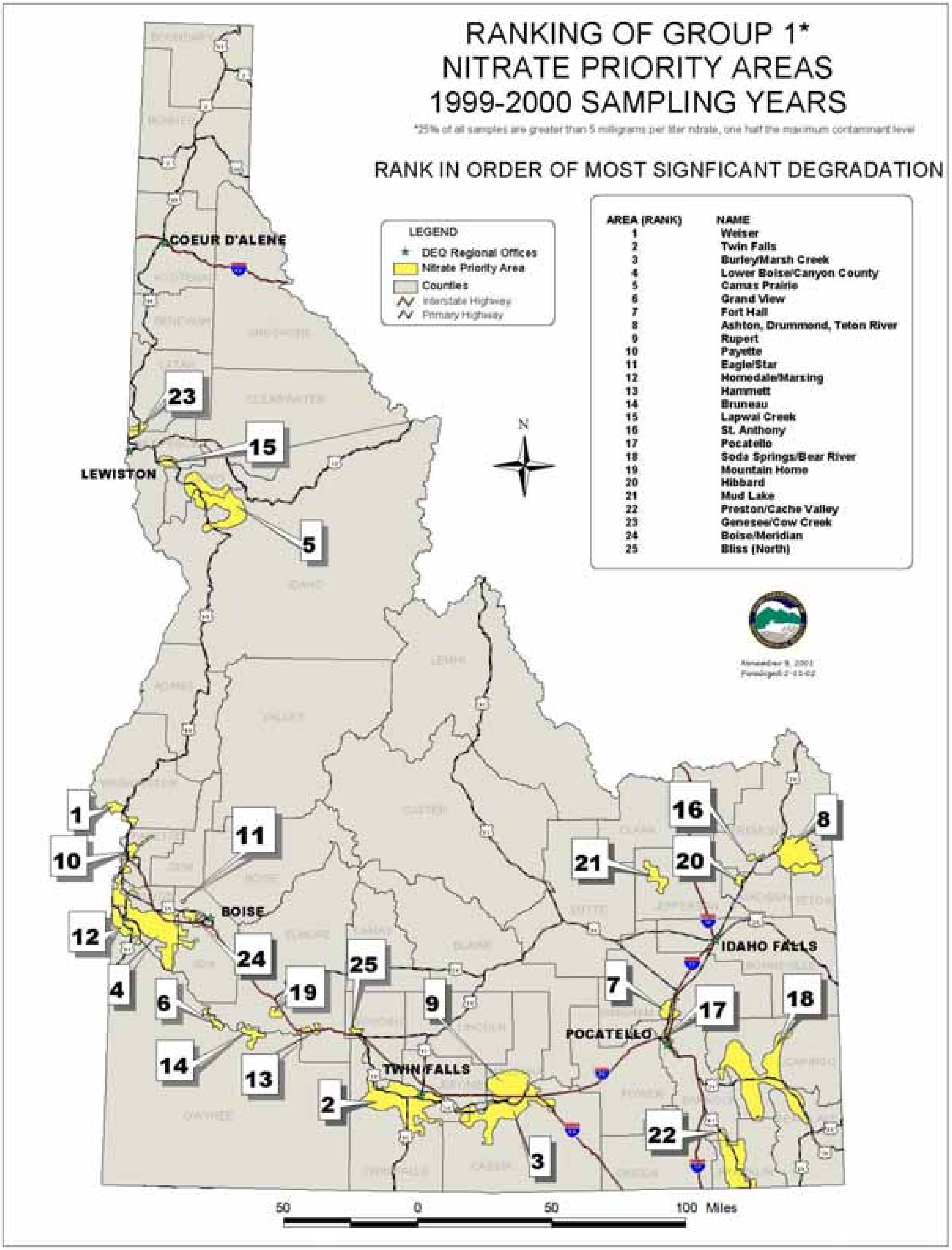

Figure 3 - 1. Nitrate Priority Areas

Local Planning and Zoning committees, municipality and community services officials, in addition to the public, should be consulted as part of the site selection process. Realizing the possible public health impacts a subsurface wastewater application site may create, public awareness may help determine what may or may not be acceptable. Careful investigation of present and potential future land uses may prevent costly planning and design activities for a parcel that is not suitable due to ongoing surrounding land uses.

The Individual/Subsurface Sewage Disposal Rules (IDAPA 58.01.03) stipulate setback requirements between the subsurface application area and the property boundary, public/private wells, distribution infrastructure, surface water, or other site specific features. The setback distances, commonly referred to as a buffer zone, are established to protect waters of the state (ground and surface water), which are sources of domestic drinking water, public health, and established infrastructure from contamination.

The 1986 Amendments to the *Safe Drinking Water Act* authorized the Wellhead Protection Program. Idaho Rules for Public Drinking Water Systems (IDAPA 58.01.08) specifies the minimum setbacks for individual subsurface application fields, but does not address systems that apply larger volumes from decentralized CS, commonly referred to as Clustered Systems (CS). It is the EoR's responsibility, as they work on the N-P Evaluation, to ascertain whether the subsurface wastewater application site(s) is/are in a Wellhead Protection Area. Placement of wells and drainfields with respect to one another are addressed by either DEQ or the appropriate PHD, depending upon the source and the land use activity. Since both subsurface wastewater disposal and drinking water wells interact with the local aquifer, the placement of each must accommodate the prior placement of the other improvement. The improvement made first has precedence.

3.3.4 Wastewater Treatment

The degree of pretreatment wastewater receives before subsurface application can be a distinguishing factor in establishing site requirements. The necessary level of pretreatment can be site and/or wastewater specific. The main consideration is always whether the soil biota can process the system effluent efficiently enough to prevent degradation of the underlying aquifer, thereby assuring present and future aquifer beneficial uses.

In some cases a change in the processing method could benefit the wastewater generator. If the process can significantly reduce the limiting constituent concentration, increased densities or commercial/industrial wastewaters may be dispersed to the subsurface appropriately. This evaluation is inherent in the engineering analysis of the proposed development, and requires that the EoR evaluate the cost/benefit associated with adding wastewater processing technology.

4.0 Evaluation Process

The following descriptions and flowchart are provided to assist the N-P consultants navigate the recommended steps to successfully complete a N-P Evaluation. The N-P Evaluation process includes the following steps and is provided as a flow chart for convenience, see Figure 4-1.

1. Meet with DEQ and/or the local health district to confirm requirements and objectives
2. Collect data
3. Analyze data
4. Generate, and submit the N-P Evaluation Report
5. Regulatory agency evaluates the report
6. Receive approval or comments based upon DEQ N-P Evaluation review.

Each of these steps is described in the following section.

4.1 Step 1: Meeting with DEQ and/or the Local Health District

Prior to performing an N-P evaluation, the developer and N-P consultant are encouraged to meet with DEQ and/or the local PHD to discuss the elements, data requirements, and objectives of the N-P evaluation. This suggestion applies for projects proposing LSAS and CS systems, seepage pits, as well as for individual on-site wastewater treatment systems.

The purpose of the meeting is to ensure that a clear understanding regarding the appropriate level of analysis for the project is achieved. In certain cases it would also be helpful for the project proponents to also meet with county planning and zoning staff to identify any issues associated with the N-P aspects of the project, which should be incorporated into the evaluation.

In some cases, such as where detailed modeling may be required, the submittal of a work plan for review should be considered. In many cases, meeting with the regulatory agencies may help the N-P consultant eliminate extraineous activities, develop a more thorough work plan, and/or streamline the N-P evaluation. Well conceived and developed work plans have expedited the N-P evaluation review and approval.

4.2 Step 2: Collect Data

Collect data that is pertinent to the N-P Evalaution level and site specific conditions. Data source may include, but are not limited to, field investigation, well driller's logs, IDWR's online well information search (http://www.idwr.idaho.gov/water/well/search.htm), DEQ's Source Water

Assessment studies: (http://www.deq.state.id.us/water/prog_issues/source_water/assessment.cfm), other local or regional ground water investigations, and field data collected in conjunction with the N-P Evaluation. Additional information required may include, but not necessarily limited to, drainfield placement, treatment system efficiency, average wastewater flows, LSAS design configuration, including orientation and placement of laterals, and location of monitoring wells.

4.3 Step 3: Analyze Data

Select and employ the appropriate level of N-P Evaluation model to process the site specific data. The model results should be reasonable based upon sound scientific theory and engineering practices.

Please be aware that the mass balance model, previously referred to as a Level 1 evaluation, can only be used as a screening tool to ascertain whether the site and proposed wastewater treatment level and loading rate will require a detailed model. DEQ has taken efforts to provide more detailed analytical ground water fate and transprot models for data analysis. While these analytical models are more capable than the mass balance screening tool, they have limitations that may not allow them to evaluate ground water impact adequately. Additionally, these models find their greatest utility in modeling scenarios that involve the use of a LSAS/CS or impacts of individual lots, where large distances to the compliance point are involved (greater than several hundred feet) and dispersive processes may be important. Also, where low to intermediate numbers of multiple sources are proposed, it may be easier to model the development-wide impacts with these tools than setting up a numerical model. Finally, in developed areas using community wells, or in large proposed developments with many drainfields and wells, a numberical flow and transport model may be the only tool capable of modeling the ground water impact with adequate assurance. These tools are discussed in Nutrient Predictive Modeling section (Section 7) of this guidance.

4.4 Step 4: Generating and Submitting the N-P Evaluation Report

An N-P Evalaution report will need to be generated. The report should clearly establish the modeling results, describe the model employed, and provide all data collected and analyzed to assist DEQ or the PHD personnel in evaluating the report.

Copies of the completed N-P evaluation should be submitted to the appropriate PHD staff and DEQ regional office contact for review, comment, and/or approval.

4.5 Step 5: Regulatory agency report evaluation

The completed N-P evaluation will be evaluated at the appropriate PHD or DEQ regional office. The assigned staff will generate an appropriate position statement. This agency position will be documented in writing.

4.6 Step 6: Approval or modification

After reviewing the N-P evaluation, DEQ will provide written comments and recommendations to the PHD, the developer, and the N-P professional. If issues or deficiencies are identified which indicate that the project, as proposed, does not meet the approval criteria, additional data may need to be collected, more detailed modeling may need to be performed, or project modifications may be necessary.

When the evaluation has demonstrated that the approval criteria have been met, DEQ will send a letter to the PHD contact, indicating such. Included in the letter will be the conditions of approval, based on the assumptions stated in the N-P evaluation. If, prior to or during the course of project implementation, differences are discovered between the actual site conditions and the assumptions used in the model that would result in differences in the estimated water quality impact, then the current N-P Evaluation approval becomes void and a revised N-P evaluation should be submitted for review.

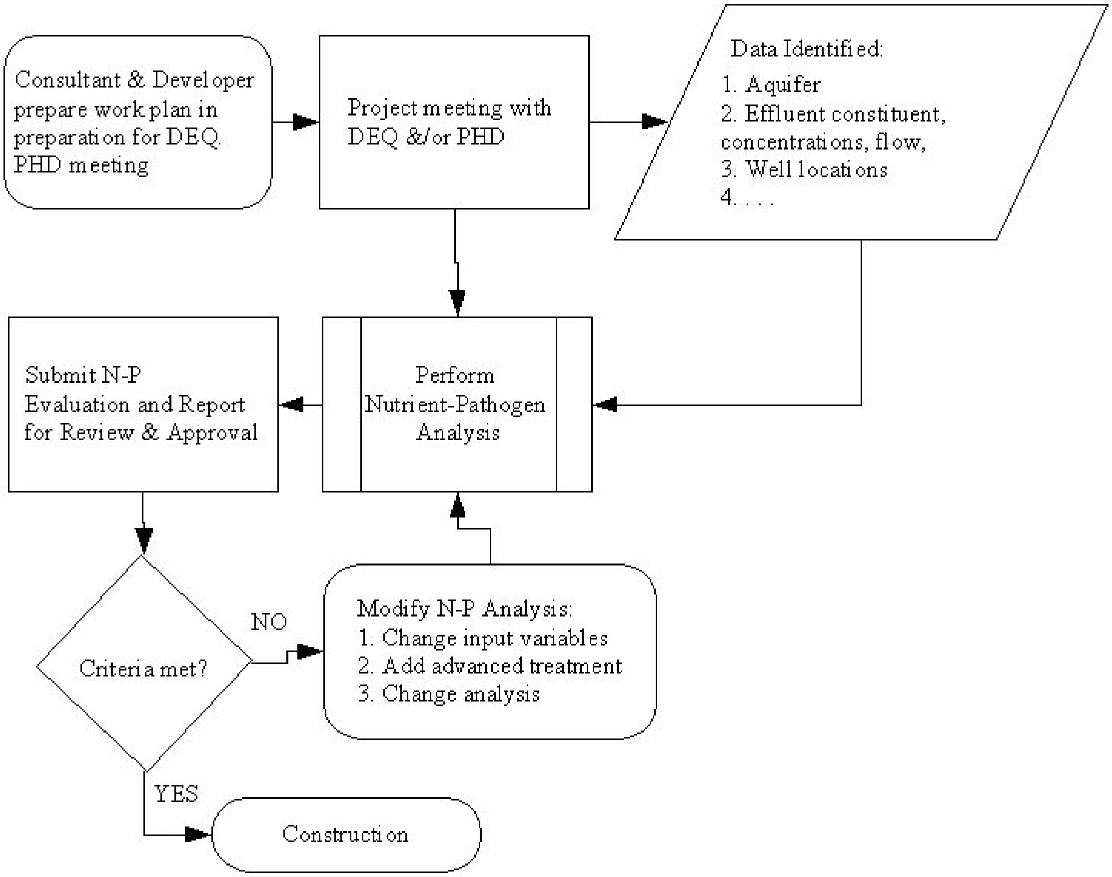

Figure 4 - 1. Nutrient - Pathogen Evaluation Flow-Chart.

5.0 N-P Evaluation Expectations

An approved N-P evaluation should demonstrate that the proposed on-site wastewater treatment system(s) will not degrade ground water or surface water quality beyond existing "background levels" and will not exceed applicable ground water quality standards.

5.1 Fate of Nutrients and Pathogens Discharged to Subsurface

With respect to nutrients, DEQ usually considers the fate of nitrate and phosphorus discharged to the subsurface:

- Nitrate is often the limiting factor in determining the appropriate number of lots and on-site wastewater treatment system design and placement, because it is the most mobile constituent of concern in domestic wastewater. Additionally, nitrates have an adverse impact on public health when the *maximum contaminant level* (MCL) is exceeded (nitrate-N >10.0 milligrams per liter [mg/l]). Note that throughout this document, references to nitrate concentration infer nitrate measured as nitrogen, often reported by laboratories as NO_3-N.
- Phosphorus can be the limiting factor when developments are located adjacent to surface water bodies. Excessive phosphorus in surface water is associated with eutrophication of streams and lakes. The process of eutrophication may cause streams and lakes to become incapable of supporting aquatic life due to excessive plant growth, reducing dissolved oxygen levels.

The evaluation of pathogen fate in the N-P process should characterize the soil and geologic conditions to a level that enables the N-P professional to verify that pathogens will be attenuated in the subsurface before impacting surface or ground water. It is typically assumed that onsite wastewater treatment systems that are designed according to the *Technical Guidance Manual* (TGM), installed properly, and used within the limits of the design, will adequately attenuate pathogens. Selected references on pathogen fate and transport are provided in Appendix 2.

5.2 Compliance Boundary Conditions

DEQ considers a predicted increase in concentration at the *compliance boundary* of 1.0 mg/l nitrate, or less, as demonstrating a negligible impact. The compliance boundary should be defined as indicated within the following conditions:

- **<u>Non-centralized water supply wells and on-site wastewater systems on individual lots</u>:** Compliance boundaries for projects with this type of configuration will vary depending on the following:
  - Clustering of wells
  - Offset of individual wells from drain fields

- Direction of ground water flow
- Stacking of drain fields in the direction of ground water flow

If all of the wells are offset from the drain fields with respect to ground water flow direction, and drain fields are not stacked along a ground water flow path, then the compliance boundary is the down gradient edge of the development. If only one of these conditions is met, then there is a compliance boundary at both the development's down gradient property boundary and the individual lot's down gradient property boundary.

Therefore, when looking at individual lot impacts, a single on-site wastewater treatment system cannot cause nitrate concentrations to increase more than 1.0 mg/l above pre-development levels as measured at the down gradient lot boundaries. The cumulative impact of the overall development also should not exceed 1.0 mg/l increase over background at the development's down gradient property boundary.

- **Central community water system:** The compliance boundary for projects with a central community water system will typically be the down gradient edge of the entire development. Nitrate concentrations at the boundary cannot increase more than 1.0 mg/l above pre-development levels as a result of the combined effect of all on-site wastewater treatment systems. Items that may impact the ground water attributes include, but are not limited to:

  1. the central drinking water well location with respect to proposed on-site wastewater treatment drain field(s),
  2. the drinking water system's proposed pumping rate,
  3. the cumulative wastewater treatment drain field(s) loading rate(s) and distribution,
  4. the ground water gradient (flow rate, and direction), and
  5. the site hydraulic conductivity.

- **Surface water bodies:** When an adjacent surface water body is hydraulically linked with ground water that is influenced by subsurface wastewater disposal, the impacts to the adjacent surface water body should be evaluated. Phosphorus is usually the chemical of concern with respect to surface water quality, but nitrogen is usually evaluated as well. Phosphorus criteria that may guide the impact evaluation will vary depending on several factors:

  - Type of water body (stream, lake, or reservoir)
  - Status of the water body with respect to listing as water quality limited for nutrients, the existence of a *Total Maximum Daily Load* (TMDL) allocation or concentration, the nature of that allocation if one exists

- Degree to which ground water nutrient contributions to the water body are included in the TMDL

For projects located adjacent to 303(d) listed water quality limited surface water bodies where TMDLs have been established that limit the nonpoint source loading allocation, then the surface water body, as well as ground water discharging to the surface water body, should be evaluated. *Constituents of concern* (COC) in this scenario are usually, but not always, nitrates and phosphorus. COC target concentrations in the surface water body should guide the evaluation.

For projects located adjacent to 303(d) listed surface water bodies, where no TMDL has been established, the N-P professional should determine whether the water body is a high priority water body. Under Idaho's Water Quality Standards, until a TMDL is developed, new or increased discharges of pollutants which have caused the 303(d) listing may be allowed only if the total load of the pollutant of concern remains constant or decreases within the watershed. IDAPA 58.01.02.054.04. Where the surface water body has not been listed as water quality limited for nutrients, the *USEPA Gold Book* (USEPA, 1986) water quality criteria values for total phosphorus will guide the evaluation. The US EPA has set TMDLs for phosphorus for the following surface water body classes;

- Streams = 0.100 mg/L
- Reservoirs = 0.050 mg/L
- Lakes = 0.025 mg/L

Discussion of other phosphorus evaluation issues is included elsewhere in this guidance. Direct coordination with DEQ is necessary to design an appropriate N-P evaluation when surface water impacts are a concern.

Table 5-1 provides a convenient permutation listing of well types, drainfield configurations, and ground to/from surface water interactions that will assist the N-P consultant in determining the level of analysis that a particular project my require.

Table 5 - 1. Site Attribute Permutations and Evaluation Recommendations.

Well Configuration	Drainfield Configuration	Surface & Ground water interaction	Recommended Evaluation
Individual	Individual	Losing	Evaluate ground water impact while accounting for surface water dilution
Individual	Individual	Gaining	Evaluate surface water impact
Common	Individual	Losing	Evaluate ground water impact while accounting for common well's cone of depression & potential GWUDI
Common	Individual	Gaining	Evaluate surface water impact while accounting for common well's cone of depression
Individual	Common	Losing	Evaluate ground water, but surface water may warrant investigation if geologic conditions & drainfield loading could reverse ground water gradient
Individual	Common	Gaining	Evaluate surface water, but ground water may warrant investigation if geologic conditions & drainfield loading could reverse ground water gradient
Common	Common	Losing	Evaluate ground water impact while accounting for surface water dilution
Common	Common	Gaining	Evaluate surface water impact

Legend:

Losing = Surface water discharging to ground water
Gaining = Ground water discharging to surface water
GWUDI = Ground Water Under the Direct Influence of Surface Water

6.0 Nutrient-Pathogen Evaluation Elements

This section describes the N-P evaluation elements, the minimum data set required, and criteria to help determine how detailed an evaluation is required for the development.

6.1 Levels of N-P Evaluation

The general term "nutrient-pathogen evaluation" refers to a set of activities that include the compilation of generally existing information, collection of site-specific information, and the completion of predictive contaminant modeling for ground water and any interconnected surface water to estimate potential water quality impacts from the proposed project.

Depending on site conditions and design factors associated with the proposed project, the PHDs or DEQ, in consultation with the developers, should determine the degree of detail that will be required in the N-P evaluation. The degree of detail in the evaluations will differ primarily due to the complexity of the development scenario and the hydrogeologic setting, the amount of site-specific data available or which will be gathered, and the data needs of the modeling which has been seleced to predict impacts.

The most basic evaluations are typically conducted by gathering the minimum background information, indicated in Table 6-1, and using simple, conservative models along with conservative input parameter assumptions to predict impacts. An example of a simple, conservative model is the nitrogen mass-balance spreadsheet (developed in Microsoft Excel™), available from DEQ. The use and limitations of this model are discussed in more detail in Section 7.3.1.

A basic N-P evaluation may suffice if the results of the predictive modeling meet the approval criteria. If that is not the case, the evaluation may be modified by gathering additional site-specific data to support alternative input parameter values, modifying design elements of the proposed project, or by using a different, more appropriate model(s).

More complex evaluations are conducted by gathering all of the background information specified for a basic evaluation along with additional site-specific information, developing a site conceptual model, and then conducting detailed modeling of project impacts based on that site conceptual model. Often this modeling will be done using analytical or numerical flow and transport models.

Examples of scenarios that might qualify as requiring a complex evaluation include
(a) cases where well pumping is of a magnitude that might be expected to significantly alter ground water flow directions or gradients,
(b) areas where hydrogeologic conditions change significantly (such as a tributary valley aquifer entering a main valley aquifer) within the projected area of impact

(c) proposals located within the zone of capture of public or private drinking water systems

(d) proposals in mountainous terrain in fractured rock environments or

(e) proposals adjacent to surface water bodies.

6.2 Evaluation Criteria

Table 6-1 provides minimum data requirements for N-P evaluations. However, the general guidance provided in this table is not a substitute for the experience and judgment required on the part of the N-P professional. Other types of information may be warranted due to the unique characteristics of a project. Also, data sources not listed may provide more useful information relative to a particular project. Examples of additional data sources for different aquifers across the state are provided in the Appendix of this guidance.

Table 6 - 1. Minimum Data Requirements.

Minimum Data Requirements for N-P Evaluations	Notes/Additional Guidance
Well driller reports for wells within ½ mile radius of the project compliance boundary	available at IDWR[a]
Map showing the project with proposed lot configuration, property lines, locations of on-site wastewater treatment systems, water supply wells, surface water features, and location of surrounding wells represented by well driller reports	generated by N-P professional or design engineer
Information on the depth to ground water, ground water flow direction, hydraulic conductivity and gradient	
Information on soil and subsurface geologic conditions at the site for evaluation of pathogen fate and nutrient migration	county soil surveys available through the NRCS[b] or test hole information available from the local district health department; geologic maps and products available through the IGS[c]
Soil descriptions from test pits excavated at the site	generated by N-P professional and witnessed by the local district health department
Ground water and surface water quality data in the vicinity of the project	Treasure Valley data available at DEQ[d] and USGS;[e] statewide data available from other DEQ regional offices, IDWR, and USGS
Use DEQ mass-balance spreadsheet or other models, as appropriate, to estimate impacts from the development	

a Idaho Department of Water Resources, 322 East Front St., Boise, ID 83702 (208) 287-4800; http://www.idwr.state.id.us/
b Natural Resources Conservation Service; this is a federal agency; contact district office in your area; http://www.nrcs.usda.gov/
c Idaho Geological Survey, Branch Office at Boise State University Math-Geology, Room 229, (208) 426-4002; http://www.idahogeology.org/default.htm
d Idaho Department of Environmental Quality, Boise Regional Office; contact Tom Neace (208) 373-0550; http://www.deq.state.id.us/
e United States Geological Survey, Water Resources Division, Idaho District; contact Deb Parliman (208) 387-1326; http://idaho.usgs.gov

7.0 Nutrient Predictive Modeling

Ground water flow and contaminant transport modeling is used in N-P evaluations as a tool to predict the impact of the proposed development on ground water quality. Surface water quality impacts are also evaluated if ground water discharges to nearby streams, lakes, or reservoirs. Nitrogen and phosphorous are the most common contaminants that will be modeled for an N-P evaluation. In most cases nitrogen will be the contaminant that dictates the necessary lot configuration, lot size, on-site wastewater treatment system type, and system placement. Phosphorus modeling may be necessary where impacts to surface water are being evaluated.

This section discusses general N-P modeling considerations, model types, modeling approaches, input parameter estimation, and default parameter values.

7.1 Factors Influencing Modeling Approach

The type of impacts which should be modeled (ground water vs. surface water) and level of modeling detail chosen (mass balance vs. analytical vs. numerical) to evaluate water quality impacts of a project are a function of several factors, including the following:

- Existing available data, the quality of that data (how well it represents the conditions at the project location), and the input parameter data requirements of the model
- Site conceptual model and the hydrologic complexity of the site
- Project layout and design
- Proposed type of on-site wastewater treatment systems (individual vs. LSAS, or CS)
- Proposed type of drinking water supply (individual vs. community)
- Approval criteria that may apply to the project (previously described in Section 5.2)
- Project budget available to collect additional data

For evaluating cumulative development impacts, the model must simulate all sources of contaminant input simultaneously (i.e., multiple contaminant source locations corresponding to the proposed on-site wastewater treatment system locations and development configuration). This will ensure that interactions between adjacent contaminant source locations (e.g., additive effects from drainfields aligned along a common flow path or the joining of adjacent contaminant plumes due to dispersion) are assessed.

7.2 Modeling Guidelines and Default Assumptions

Below are some basic initial modeling considerations and assumptions:

- Chemical transport of nitrogen and phosphorus should initially be modeled conservatively as non-reactive species. Typically, no consideration is given to nitrogen or phosphorus attenuation during transport through the vadose or saturated zone, although such an analysis could be proposed to the PHD or DEQ for approval.
- Contaminant transport simulations should project plume migration at time periods that effectively represent steady-state conditions after on-site wastewater treatment system use begins.
- The effects of recharge from precipitation or irrigation and the nutrient load associated with the recharge may or may not be included, depending on the specifics of the model selected.

7.3 Model Types

The models commonly used to conduct N-P evaluations can be classified into three groups: mass-balance screening models, analytical models, and numerical fate and transport models. This section describes the general characteristics of these three types of modeling approaches and provides general guidelines on the estimation of parameter values that are required.

7.3.1 Mass-Balance Screening Spreadsheet Model

Mass balance models depend primarily on an accounting of the nutrient mass and water volume attributable to various compartments in the system of interest to arrive at a final predicted concentration. The simulation of attenuation processes by most mass-balance models is typically limited to dilution although the effects of other processes such as dispersion can be crudely approximated.

The mass-balance screening spreadsheet model developed by DEQ models the dilution of effluent as it mixes with ground water and local recharge. The mass balance spreadsheet is intended to be used as a conservative screening tool for evaluating impacts. If the layout of proposed projects involve large lot or overall parcel sizes, where travel distances to compliance points is significant, the dispersion of constituents in ground water may be important but will likely be underestimated by mass balance techniques. If the layout of drainfields is such that stacking of drainfields along the direction of ground water flow occurs, the estimation of impacts at the development level will be underestimated. A screenshot of the model interface is shown in Figure 7-1. The model input parameters describe three sources of mass and flow: wastewater effluent, aquifer, and areal recharge.

Site parameters which influence effluent mass and flow are the number of homes (drainfields) in the development, the daily effluent flow rate per home, and the effluent nutrient concentration as it leaves the drainfield.

Aquifer parameters include the hydraulic conductivity, the hydraulic gradient, the mixing zone depth, and the aquifer width perpendicular to flow. Procedures to estimate appropriate site-specific values for hydraulic conductivity and gradient are discussed in Section 8.1 of this document.

The estimation of the mixing zone depth should be based on the scale of the projected impact; that is, whether the impact of individual systems on adjacent lots or development-wide impacts are being evaluated. For individual systems, the distance from the drainfield to the compliance boundary is typically much less than when considering development-wide impacts. A mixing zone depth of 15 feet is appropriate for the evaluation of individual lots. A larger value is justifiable for development-wide impacts based on the average distance from the drainfields to the appropriate compliance boundary. If this distance is 500-1000 feet, the mixing zone depth should be 30 feet. For distances greater than 1000 feet, a depth of 60 feet should be used. The recommended values for these distances are based on mixing depths calculated using the Domenico analytical solution and dispersivity values estimated from the Xu and Eckstein (1995) empirical equations. The values generally represent those depths in the aquifer where the majority of the chemical mass is present.

The aquifer width should be measured perpendicular to the direction of groundwater flow. For individual drainfield evaluations, use the width of the drainfield perpendicular to flow . For development-wide impacts, use the smallest width that includes all the drainfields.

Natural recharge amount can be estimated by a variety of means. The spreadsheet provides an empirical formula, based on a compilation of field studies of infiltration, which uses total annual precipitation (http://www.gsi-net.com/Publications/SAM.pdf). Site-specific, local, or regional estimates of recharge from precipitation may also be available from water resource reports, aquifer studies, and ground water flow models for specific aquifers.

The default value for total nitrogen in precipitation is 0.64 mg/liter. This value represents the average of annual, precipitation-weighted samples taken at five sites in Idaho that are part of the National Atmospheric Deposition Program (http://nadp.sws.uiuc.edu/).

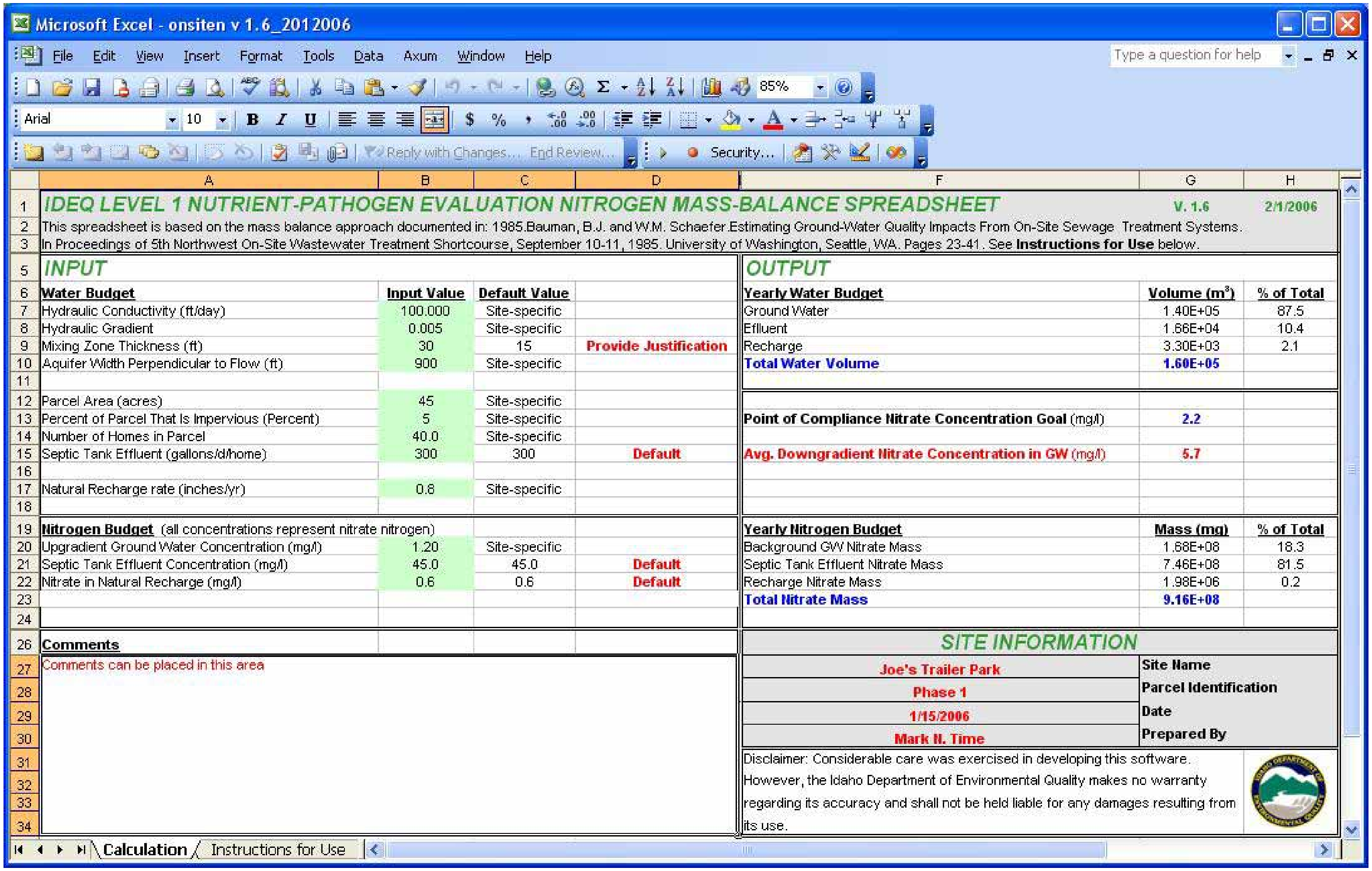

Figure 7 - 1. Example Mass Balance Screening Spreadsheet

7.3.2 Analytical Modeling

Analytical ground water fate and transport models, through their ease of use and incorporation of additional transport and attenuation processes, provide useful alternatives to mass-balance techniques or numerical models for making predictions of project impacts. A tradeoff to their ease of use is that they are typically developed to model a specific set of boundary conditions, which may not be realized at the site of interest. Two examples of such models are the *Domenico solution* (Domenico and Schwartz, 1990)[3] and the semi-analytical *Horizontal Planar Source* (HPS) model (Galya, 1985).[4]

The commonly used Domenico solution models the transport of contaminants in ground water, under unidirectional flow via advection and dispersion. It incorporates the attenuation processes of sorption, decay, and dispersion in three dimensions. It typically assumes a rectangular vertical patch source, oriented perpendicular to the direction of ground water flow and located at and below the water table. As a result of this source configuration, some intermediate method must be used to estimate the source concentration in ground water representing the mixed effluent-ground water condition as well as the depth of mixing of the effluent with groundwater under the source area. There may also be limits to the accuracy of the solution at distances close to the source. Though typically used to simulate individual sources it can be manipulated to simulate the impacts of multiple sources through the use of the theory of superposition.

The Domenico solution is easily programmed using spreadsheet techniques and many examples of its implementation in this format are available. Figure 7-2 is a screenshot of the interface for one such formulation. This spreadsheet has been adapted by DEQ from a version developed by the Pennsylvania DEP. The Domenico solution allows the calculation of estimated ground water concentrations at varying distances from the source and depths below the water table.

The HPS model is similar to the Domenico solution in terms of the boundary conditions which are assumed and the processes which are modeled, but HPS differs in the configuration of the source area. The HPS model assumes the configuration of a rectangular horizontal planar source of contaminants at the water table surface similar to that of wastewater effluent leaving a drainfield. The impact of either individual or multiple sources of contamination at downgradient locations can be simulated. An estimate of ground water concentration in the source area does not need to be estimated since the mixing of the source with incoming ground water is accounted for. A disadvantage of the model is that it is only available in a DOS version and developing input files for simulations, particularly for multiple sources, can be laborious. This model is available as a DOS executable through the

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[3] Domenico, P.A. and G.A. Robbins. 1985. A new method of contaminant plume analysis. Ground Water. V. 23. no. 4. p. 476-485.

[4] Galya, D.P.1987. A horizontal plane source model for ground-water transport. Ground Water. V. 25. no. 6. p. 733-739.

International Ground Water Modeling Center
(http://typhoon.mines.edu/software/igwmcsoft/)

Neither model is able to simulate the impact of well pumping on contaminant transport, which may be significant where pumping centers are created by the clustering of multiple wells for individual lots or locating community wells downgradient of a proposed development. For these cases, the use of a numerical model may be necessary.

These models find their greatest utility in modeling scenarios that involve the use of a LSAS/CS or impacts of individual lots, where large distances to the compliance point are involved (greater than several hundred feet) and dispersive processes may be important. Also, where low to intermediate numbers of multiple sources are proposed, it may be easier to model the development-wide impacts with these tools than setting up a numerical model.

There are certain similarities and differences in input parameter requirements for the Domenico analytical model compared to that of the mass-balance models.

The same effluent characteristics must also be estimated but are used in a different manner than in the mass balance models. In the analytical model they are used along with aquifer properties in a mixing calculation to rather than being input directly.

Estimation of aquifer properties such as the hydraulic conductivity and gradient are no different. The width and depth of the rectangular source zone (analogous to the aquifer width perpendicular to flow and the mixing zone depth parameters for the mass balance models) in ground water must be estimated. The estimation of width is similar, at least for single drainfield sources, to that used for the aquifer width perpendicular to flow parameter.The depth of the source zone is calculated through the mixing analysis, using the ratio of the effluent to ground water flows and some measure of dispersivity, rather than using the rules of thumb described in the section on mass balance modeling. One example of a mixing analysis to estimate the depth of the source zone uses equation 38 in the USEPA Soil Screening Level guidance (1996).

Areal recharge is typically not included in the analytical solution.

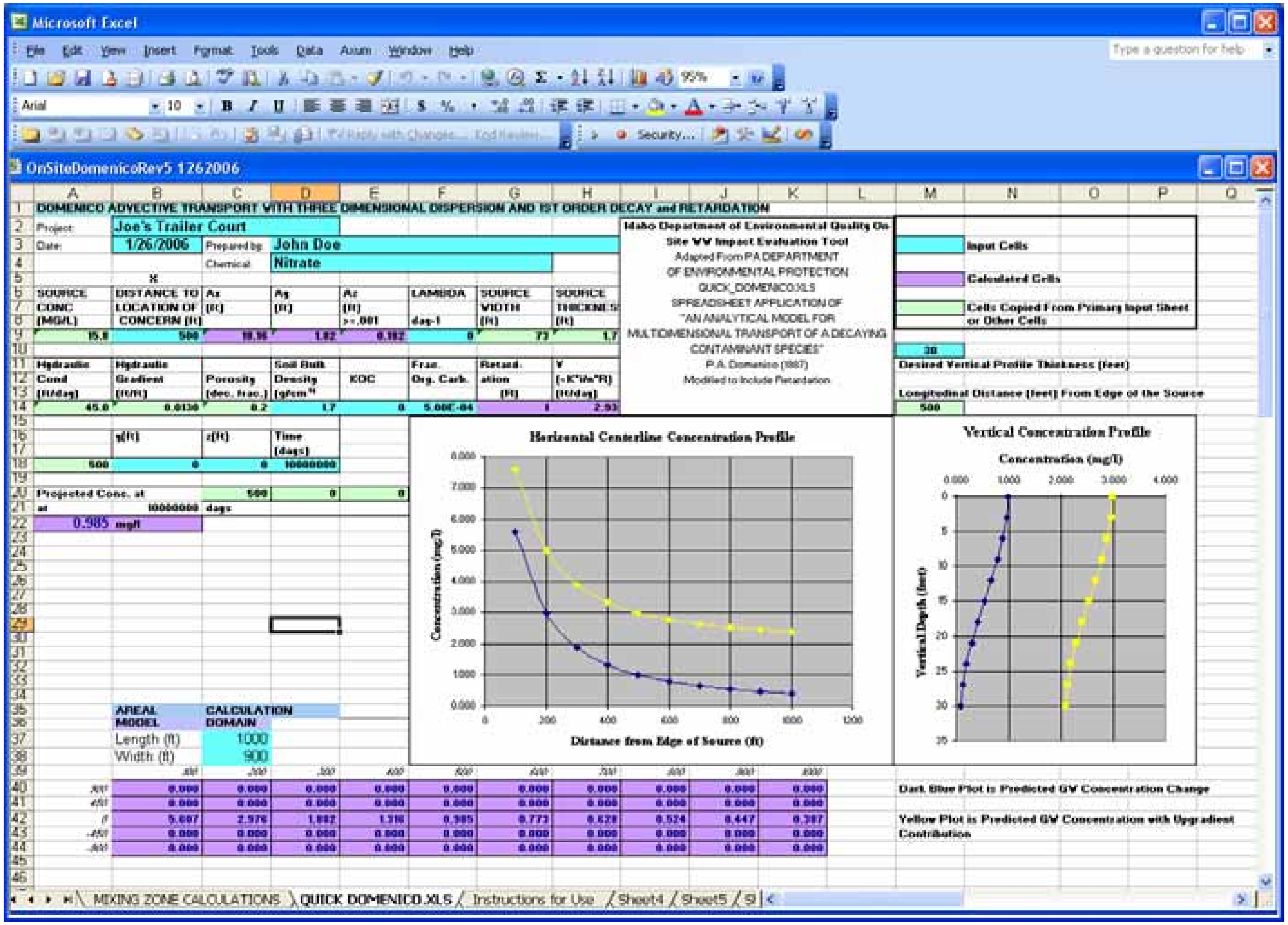

Figure 7 - 2 Example of DEQ's Domenico Analytical Fate and Transport Model spreadsheet.

7.3.3 Numerical Flow and Transport Models

Numerical flow and transport models (such as MODFLOW/MT3D, for example) may provide the most realistic simulation of the important processes affecting nutrient fate and transport in ground water and surface water. The data requirements to simulate these processes are often quite daunting, however, and site-specific estimates of the necessary parameters are typically lacking.

It is generally desirable to define the model domain with physical boundaries, such as impermeable geologic contacts or hydraulically connected surface water features.[5] Impermeable geologic contacts can be represented as no-flow boundaries. Surface water features are often represented as constant head or constant flux boundaries.

Nutrient predictive modeling is usually performed on a local scale, and the distance to such features may limit their use as model boundaries. In most cases, artificial boundaries (sometimes called "hydraulic" boundaries) must be designated by the modeler. Hydraulic boundaries can be no-flow boundaries, represented by streamlines (lines perpendicular to equipotential lines), or boundaries with known hydraulic head (constant head boundaries), represented by equipotential lines. These features are less desirable model boundaries than physical features because they are not permanent and can change with time. Hydraulic boundaries must be set far enough from the area of interest (i.e., the drainfield locations) so that they do not influence the flow pattern resulting from the introduction of wastewater from the drainfields.

Drainfield source locations may be modeled as injection wells placed in the locations of the proposed drainfields or as area recharge over zones sized to represent the drainfield footprint. For grid-based models, the grid must be sized appropriately in both horizontal and vertical dimensions to represent the size of the individual nutrient sources (both for wells and areally distributed nitrate introduction) and to allow for an accurate simulation of vertical dispersive mixing processes. If injection wells are used the depth of injection should be into cells no thicker than 15 feet while if areal recharge methods are used grid cells should be no larger than 100 to 200 ft^2 in area.

Surface water features found in the model domain, such as agricultural drains, canals, springs, streams, rivers, lakes, and reservoirs must be considered. These features may represent a source of recharge or a point of discharge to the aquifer. Their water quality may be adversely impacted by the development. Surface water

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[5] For an overview of modeling, including model boundaries, see (1) Kresic, N. 1997. Quantitative Solutions in Hydrogeology and Ground water Modeling. Lewis Publishers, Boca Raton, 461 p. or (2) Anderson, M.P. and W.W. Woessner. 1992. Applied Ground water Modeling, Simulation of Flow and Advective Transport, Academic Press, New York, 381 p.

features hydraulically connected to an underlying aquifer can be represented as a constant head, constant flux, or variable flux boundary.

In all cases, it is necessary to base boundary conditions on the physical and hydraulic characteristics of the project location and to document why the boundary conditions were chosen. Flux boundaries must be as accurate as possible, even if they are adjusted during model calibration. Data from regional or local water budget assessments are often necessary to assign reasonable flux boundaries.

N-P modeling is typically performed in a “predictive” mode, without the benefit of being able to directly measure the development’s impact to ground water or surface water. Therefore, formal calibration of the contaminant fate and transport model component is usually not possible. The process of numerical model calibration typically involves the adjustment of selected model inputs in order to achieve agreement with observed properties of the system.Typical properties which are used to assess the adequacy of calibration include observed head values in wells located in the model domain, typical head values from the regional flow regime, modeled versus observed hydraulic gradient, and the magnitude of both water and mass fluxes for inputs and outputs. In addition, the input/output mass balance error for both water flow and mass flux should be acceptable.These calibration measures should be documented in the N-P report.

8.0 Nutrient Modeling Parameter Estimation

The model input parameters will vary depending upon the model (or models) selected to conduct the evaluation.

For ground water flow and transport modeling input, parameters can be grouped into the categories of aquifer properties, source characteristics, and site characteristics:

- **Aquifer properties** include hydraulic conductivity, hydraulic gradient, ground water flow direction, porosity, dispersivity, and water quality characteristics such as background chemical concentrations.
- **Source characteristics** include the effluent chemical concentrations, volumes, and source dimensions and locations.
- **Site characteristics** include the size and configuration of the project with respect to ground water flow and the amount and quality of natural ground water recharge from precipitation.

In addition to these parameters, if surface water impacts are to be evaluated, input parameters and data such as background water quality data, discharge characteristics of streams, ground water-surface water relationship, and water volumes and bathymetry for lakes and reservoirs may need to be developed. Estimation of these parameters is discussed in detail in Section 9.0, Surface Water Evaluation.

8.1 Aquifer Properties.

- **Ground water flow direction and hydraulic gradient for the uppermost aquifer.** This information can be obtained in a number of ways. Maps of the potentiometric surface of many of the major aquifers across the state, developed from mass water level measurements in representative wells and typically on a regional scale, have been constructed.

  More localized representations of the potentiometric surface and direction of flow may be constructed from the use of water level measurement taken by agencies such as the United States Geological Survey and the Idaho Department of Water Resources. These agencies regularly gauge a network of wells across the state and make these measurements available to the public. This information can be accessed on the internet at: http://www.idwr.idaho.gov/hydrologic/info/obswell/ and http://waterdata.usgs.gov/id/nwis

  When using this type of data the effort should be made to ensure that the wells are similarly completed in the uppermost aquifer (i.e. similar depths and screened intervals) and that data are comparable from the standpoint of time of year for sampling, in order to remove variation due to seasonal effects.

  A map may also be constructed by measurement of water levels from a dedicated network of at least three monitoring wells constructed in the uppermost aquifer at the site. An accurate elevation and location survey should be performed to establish the relative elevation and location of the monitoring wells. The wells should be located to provide for adequate triangulation and separated by enough distance to allow calculation within the accuracy of the measurements taken.

  The use of water level measurements taken from local domestic and irrigation wells or well logs is generally discouraged unless it can be confirmed that all wells are similarly completed in the uppermost aquifer and there are no residual pumping effects from local use

- **Hydraulic Conductivity.** A broad range of methods exists for the estimation of aquifer hydraulic conductivity. These methods can be considered in the context of a hierarchy in terms of data quality and uncertainty. The highest quality data is that acquired from properly performed aquifer tests by pumping of on-site wells representative of the uppermost impacted aquifer and which includes measurements in comparable, nearby observation wells. A discussion of the critical issues involved in the performance and analysis of aquifer tests is provided below.

  Data of lower quality might be represented by an aquifer test, for example, that was adequately performed in the same aquifer but at a significant distance from the site, did not have observation wells, or had some compromises in their performance or analysis.

Further down the data hierarchy are conductivity values derived from single well pump tests, specific capacity test data from well logs, or zonal estimates derived from calibrated ground water flow models for the aquifer that may be impacted.

Still lower in quality are estimates, using quasi-empirical equations or models such as Rosetta (U.S. Salinity Laboratory, USDA-ARS, 1999),[6] to evaluate grain size data of samples collected from site borings. A problem with these methods is that the equations are often based on materials from a specific particle size range and may not be applicable to the particle size distribution at the site of interest. An associated method, particularly useful for fine-grained unconsolidated aquifers is to analyze samples in the laboratory for hydraulic conductivity. A problem with these methods is the limited volume of the aquifer that is tested.

The data of lowest quality is that derived from the general literature, such as textbook values or data compilations.

8.1.1 Aquifer Testing Guidelines for Estimating Hydraulic Conductivity

Given the significance of hydraulic conductivity in estimating impacts from proposed projects, the importance of conducting and analyzing the data collected from an aquifer test in a sound manner to provide representative and defensible conductivity estimates cannot be overemphasized. Numerous references are available that provide guidance on conducting good aquifer tests. Some of these references are provided in the appendices of this guidance. This section provides a summary of the general points that deserve attention during the planning, performance, and analysis of an aquifer test.

8.1.2 General Guidelines

- Collect adequate numbers of data points at the appropriate times. Pretest data should also be collected in order to identify any temporal trends in water levels that may be occurring.
- Water level measurements should be accurate to at least 0.01 feet (3 mm).
- Select a pumping rate that will be sufficient, given the estimates of potential conductivity, to generate a measurable drawdown response, yet not so high (in the case of unconfined conditions) to significantly dewater the well (> 25% of the initial saturated thickness).
- The discharge rate should be monitored frequently during the test and not allowed to vary more than 5 percent.
- Ensure that pumped water is disposed at locations that will not recharge the area being pumped.

[6] U.S. Department of Agriculture-Agricultural Research Service Salinity Laboratory. 1999. Rosetta (computer model authored by Marcel Schapp) available for download at http://www.ussl.ars.usda.gov/MODELS/rosetta/rosetta.htm#Abstract

- For newly installed wells ensure that the well has been adequately developed prior to aquifer testing.
- Collect recovery data as well as pumping data.
- Include measurements from an observation well(s) if available.
- Ensure that logs detailing the construction of the well being tested or measured and the lithology encountered during drilling of these wells are available.
- When conducting single well specific capacity tests evaluate the potential for well-bore storage effects and correct for drawdown in tests in unconfined aquifers.

8.1.3 Slug Tests

- Conduct tests on at least three wells.
- Ensure that a sufficient amount of early-time data is collected.
- Conduct both slug in and slug out tests at each well.
- Ensure that the hydraulic response measured is proportional to the size of the slug used in the test.

8.1.4 Analysis

- Ensure that the method of analysis used is appropriate to the data collected and the conceptual model of the aquifer being evaluated.

- **Aquifer Thickness.** Aquifer thickness should be determined by an analysis of on-site boring logs and well driller reports for nearby wells. Several options are available to interpret this information. These include the difference between static water level and total well depth, accumulative thickness of producing zones, thickness of screened intervals, difference between the bottom of confining units and total well depth (for confined or semi-confined aquifers). Which method is most appropriate for the site should be determined by the N-P professional with justification provided in the N-P report.
- Background concentrations of nitrate, phosphorus, or other constituents should be determined by sampling on-site monitoring wells or by compiling existing nearby, upgradient local and regional data. Local and regional data may be obtained from a number of sources including the statewide groundwater monitoring network maintained by IDWR, the U.S Geological Survey, Public Drinking Water Systems (IDEQ), Health District mortgage survey sampling, and local and regional monitoring studies performed by IDEQ. Care should be taken to ensure that all wells chosen to represent the water quality of the uppermost aquifer are constructed similarly and truly sample water from the uppermost portions of the aquifer.

The sources of all background concentration data should be clearly identified, including the dates of sampling. Recent data (within the last two to four years) is to be preferred over older data. When multiple data points are used to determine the background concentration the method used to combine that data should be described and justified.

- **Aquifer porosity**: Aquifer porosity is typically determined by a laboratory analysis of soil bulk density (to calculate porosity) from samples collected at the site, or from text book values for typical aquifer materials. Aquifer porosity is different from and is typically greater than effective porosity. Effective porosity is the porosity through which the majority of flow occurs. Effective porosity is the preferred parameter to be used in transport modeling but it is also the more difficult parameter to estimate or measure in the field. A general guideline that may be used for effective porosity is that for unconsolidated sediments values ranging from 0.15 to 0.3 are reasonable while for fractured rock settings values are typically no greater than 0.2 and are often much smaller.

Dispersivity. Dispersivity is shown to be scale-dependent (e.g., Xu and Eckstein, 1995).[7] Much of the scientific literature documents the existence of long, narrow plumes (for conservative contaminants or tracers), reflecting low dispersivity values, especially in the transverse direction. Plume lengths in coarse alluvial sediments are commonly in the range of 500 to several thousand feet. References to many of the publications reviewed are found in Appendix 2 under the “Dispersion and Dispersivity” heading.

For purposes of N-P evaluations where dispersivity is required as an input parameter, the default value for longitudinal dispersivity should be determined using the expected estimate of nitrate plume length and the analysis of field measured dispersivity data presented by Xu and Eckstein (1995) as corrected by Al-Sumaiyan (1996)[8]. Their analysis indicated that longitudinal dispersivity may be represented by Equation 1:

$$\alpha_L = 0.82\,(\log_{10}L)^{2.446}$$

Equation 1. Calculation of longitudinal dispersivity.

where α_L is longitudinal dispersivity (in meters) and L (in meters) is the field scale, which can be interpreted to represent the estimated nitrate plume length.

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7 Xu, M. and Y. Eckstein. 1995. Use of weighted least-squares method in evaluation of the relationship between dispersivity and field scale. Ground Water. v. 33, no. 6, pp. 905-908.

8 Al-Suwaiyan, Mohammad S. July-August 1996. Discussion on “Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale” by Xu and Eckstein, Discussion Ground Water, V. 34, No.4, November-December 1995.

Based on the data compiled by Gelhar et al. (1992)[9] it is reasonable to estimate the transverse (horizontal) dispersivity and the vertical dispersivity by multiplying the estimated longitudinal dispersivity by 0.1 or 0.01, respectively.

Table 8 - 1. Calculated Longitudinal Dispersivity Values for Selected Plume Lengths.

Plume Length (feet)	Dispersivity (feet)		
	Longitudinal	Horizontal	Vertical
100	7.1	0.71	0.07
200	11.1	1.11	0.11
300	14.0	1.40	0.14
500	18.2	1.82	0.18
600	19.8	1.98	0.20
750	22.0	2.20	0.22
1000	24.9	2.49	0.25

Longitudinal dispersivity values were calculated using the Xu and Eckstein (1995) empirical relationship, as corrected by Al-Suwaiyan (1996). Horizontal and vertical dispersivity values are 0.1 and 0.01 of longitudinal values, respectively.

[9] Gelhar, L.W., C. Welty, and K.R. Rehfeldt. 1992. A critical review of data on field-scale dispersion in aquifers. Water Resources Research. V. 28, no. 7, pp. 1955-1974.

Table 8 - 2. Summary of Modeling Parameter Estimation Guidelines.

Parameter	Value or Description
Flow model	steady-state simulation of uppermost aquifer
Solute transport model	transport predictions until steady-state conditions are achieved; simulate nitrate and phosphorus as non-reactive
Grid design (when applicable)	refine ("customize") grid in the area of interest; cell sizes near drainfields must be small enough to simulate drain field configuration (e.g., 5 to 20 feet) size of adjacent cells in a "customized" or refined grid cannot increase or decrease by more than 1.5 times in any direction
Aquifer top/bottom elevations and model layers	determined by review of well driller reports and existing scientific literature
Hydraulic conductivity	determined by one or a combination of: (1) aquifer pumping tests; (2) slug tests in at least three wells; (3) specific capacity tests (4) quasi-empirical modeling using Rosetta (U.S. Salinity Laboratory) or grain-size analysis in conjunction with an empirical formula; or (5) laboratory analyses (i.e., permeameter procedures);
Gradient of uppermost ground water surface	determined by water level measurements in monitoring wells or review of existing regional data
Effective porosity	assume 0.20 to 0.35 for medium-sized granular materials assume ≤0.20 for fractured bedrock;
Aquifer recharge	assume areally-distributed recharge on a model-specific basis;
Dispersivity	$\alpha_L = 0.82 (\log_{10} L)^{2.446}$ where α_L is longitudinal dispersivity (in meters) and L (in meters) is the field scale which can be interpreted to represent the estimated nitrate plume length; assume α_{TH}(transverse-horizontal dispersivity) = $0.1\alpha_L$ assume α_{TV} (transverse-vertical dispersivity) = $0.01\ \alpha_L$
Wastewater flow per drainfield	300 gal/day (assumes four bedroom home); see Technical Guidance Manual (pages 113-115) for other flow rates
Nitrate concentration in wastewater	50 mg/l;[a,b,c,d] (assumes 100% conversion of all N forms to nitrate; nitrate measured as N). Represents average of the values from cited references
Phosphorus concentration in wastewater	12 mg/L [a,b,c,d] Value represents average from cited references.
Nitrate concentration for enhanced nutrient treatment systems	based upon product specific DEQ approved nitrate reductions.

a Small Scale Waste Management Project, University of Wisconsin, Madison. 1978. Management of Small Waste Flows. EPA 600/2-78-173, NTIS Report PB 286 560, September 1978. 804 pp. Table A-113 Septic Tank Effluent Quality - Field Sites.

b USEPA, 1980. Design Manual: Onsite Wastewater Treatment and Disposal Systems. Office of Water Program Operations. EPA 625/1-80-012, October 1980. 391 pp. Tables 4-3 and 6-1

c USEPA, 2002. Onsite WastewaterTreatment Systems Manual. Tables 3-7, 3-8, 4-10, and 4-11. EPA/625/R-00/008. February 2002.

d McCray et.al, 2005. Model Parameters for Simulating Fate and Transport of On-Site Wastewater Nutrients. Ground Water. Volume 43. Number 4.Pages 628-639.

8.2 Source Characteristics

- **Effluent volume**. Default values for wastewater volume are 300 gallons per day for each drainfield. This value is taken from the DEQ Rules for Individual and Subsurface Sewage Disposal and represents the flow to be assumed for a four bedroom single family dwelling. In some locales there is a requirement to consider higher flows (such as for potential accessory dwelling units) if the average lot size exceeds some threshold value.
- **Effluent Nutrient Concentration**. The assumed default total nitrogen and total phosphorus concentrations of wastewater effluent leaving each drainfield are 50 and 12 mg/l, respectively.

The total nitrogen concentration is derived from several sources. It is approximately the 50th percentile value for ammonium-N cited by McCray et. al (2005)[10] in their recent data compilation. It is also approximately the average value, based on the mean TN loading from Tables 3-7 and 3-8 and for nine studies cited in Tables 4-10 and 4-11 of the USEPA 2002 Design Manual.

The total phosphorus concentration is derived from the 50th percentile value for phosphate concentration of wastewater effluent data compiled in McCray et. al (2005)[10]. This value was divided by 0.85 to adjust for the percentage that phosphate contributes to total phosphorus in wastewater effluent

All nitrogen is assumed to be in the nitrate form and all phosphorus in the orthophosphate form. Adjustments to nitrate input concentrations may be considered for systems utilizing enhanced nutrient treatment employing anoxic denitrification, or where other site-specific factors (e.g., geochemical conditions resulting in denitrification) warrant adjustment. In addition, if non-residential wastewater flows are proposed as part of the development, the wastewater quality of these flows should be discussed with the Health Districts and/or DEQ prior to use in a N-P evaluation.

8.3 Site Characteristics

Amount and Nitrogen Concentration of Areal Recharge. Natural recharge amount can be estimated by a variety of means. One empirical formula, based on a compilation of field studies of infiltration, uses total annual precipitation (http://www.gsi-net.com/Publications/SAM.pdf). Site-specific, local, or regional estimates of recharge from precipitation may also be available from water resource reports, aquifer studies, and ground water flow models for specific aquifers. The default value for total nitrogen in precipitation is 0.64 mg/liter. This value represents the average of annual, precipitation-weighted samples taken at five sites

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10 Model Parameters for Simulating Fate and Transport of On-Site Wastewater Nutrients. John E. McCray, Shiloh L. Kirkland, Robert L. Siegrist, and Geoffrey D. Thyne. Ground Water. Volume 43. Number 4. Pages 628-639.

in Idaho that are part of the National Atmospheric Deposition Program. This data is available at http://nadp.sws.uiuc.edu/.

9.0 Surface Water Evaluation

Modeling the impacts of proposed projects on surface water may involve gathering different types of data, compared to ground water evaluations. The types of data which may be needed and the type of analysis required are partially dependant on the beneficial use status of the surface water body and the nutrient criteria which apply to that water body.

This section discusses the data needs and modeling approaches for surface water evaluations. While phosphorus is oftentimes the limiting nutrient in surface water evaluations, both nitrogen and phosphorus should be addressed by the analysis.

9.1 General Surface Water Evaluation Considerations

It is assumed that an evaluation will be needed where a project is located directly adjacent to a surface water body. For projects where some portions of the development are directly adjacent to a water body and other portions are not, discussions with DEQ should take place to determine which portions of the development have the potential to impact the surface water body.

It may also be necessary to evaluate surface water impacts from a proposed project if drainfield effluent from the project enters ground water with subsequent discharge to a nearby surface water body. Determination of a maximum fixed distance of a drainfield from a surface water body beyond which an analysis need not be completed is not feasible and should be determined on a site-specific basis based on the hydrologic conceptual model of the site and in consultation with DEQ staff. For example, in cases where a Total Maximum Daily Load (TMDL) has been developed for a surface water body, critical acres adjacent to the water body may have been identified as contributing to the nutrient load. If the project is located within this critical acreage, an evaluation of nutrient impacts should be completed.

It is typically assumed in these situations that ground water is hydraulically connected to surface water. If data can be presented to document the lack of a hydraulic connection an analysis may not be needed. Alternatively, if a conservative “worst case” analysis, which assumes a connection, indicates acceptable impacts, significant additional data gathering may not be needed.

9.2 Evaluation Procedures

First, the beneficial use status and target criteria which apply for the water body should be determined. The following questions should be answered if possible:

1. Is the water body a water quality limited segment? If yes, is the limitation for nutrients? This information can be obtained by reference to Section 5 of the DEQ (2005) Integrated 303(d)/305(b) Report or by searching the interactive mapping website at: http://mapserver.deq.state.id.us/Website/deqwaters/viewer.htm.
2. Has a TMDL been developed? If yes, does ground water discharging to the water body have nutrient concentration limits?
3. Are there load allocations for non-point sources (NPS)? If yes, does the NPS load allocation include onsite wastewater systems?

If the answer to question 2 above is yes, the appropriate DEQ regional office contact should be consulted to obtain details regarding the TMDL criteria and targets.

If ground water discharging to surface water has had nutrient concentration targets established the surface water evaluation may consist of fate and transport modeling of the ground water to determine if those limits would be exceeded.

For developments adjacent to surface water where a TMDL has been established as a NPS load allocation these steps should be followed in completing a nutrient analysis.

1. Calculate the development's anticipated nutrient load and compare to the TMDL non-point source (NPS) allocation.
2. Take the current NPS loading and, using the nutrient reduction target identified in the TMDL, calculate the load reduction required under current conditions.
3. Calculate the nutrient load reduction needed to mitigate anticipated nutrient project impact by adding the loadings from steps 1 and 2.
4. Develop a nutrient mitigation plan.

For developments adjacent to surface water that are water quality limited for which no TMDL has been established or which are not water quality limited the applicable concentrations listed in the approval criteria section (Section 5.2) would apply as targets. For these developments the impact analysis should determine the increase in concentration, above background, in the surface water body resulting from the additional loading. This final concentration should be compared to the appropriate N-P evaluation criteria. All nutrient flow pathways to the surface water body should be accounted for in the analysis. If background water quality data indicate an existing exceedance of the applicable criteria, mitigation of the projected impacts of the project may be needed to prevent additional increases in concentration.

In many cases, the evaluation of nutrient impacts to surface water bodies can be completed using some type of mass balance calculation. The specific calculation methodology will vary, depending on the type of surface water body involved, the hydrology of the project area, and the processes which are included. Methodologies may vary from relatively simple two-compartment mixing of ground water with stream flow, to more complex multi-compartment models for lakes and reservoirs (Nurnberg and LaZerte, 2004).[11]

9.3 Mixing Zone Analysis

A mixing zone analysis may be conducted in which a portion of the surface water flow (in the case of streams and rivers) or volume of the surface water body (for lakes and reservoirs) is mixed with discharging groundwater. The resulting nutrient concentrations must meet applicable concentration criteria and the size of the mixing zone must not exceed certain limits.

Minimum data necessary to complete a mixing zone analysis for a moving surface water body include:

- An estimate of the lowest seven-day average daily streamflow expected to occur during a ten year period (7Q10)
- Background stream concentrations for the nutrients of concern
- Stream length along which the ground water discharge from the development occurs
- Ground water aquifer discharge volumes based on aquifer hydraulic properties (hydraulic conductivity, gradient, and cross-sectional area of flow to the stream) and
- Ground water concentrations for the nutrients of concern at the point of discharge to the surface water body

Minimum data requirements for mixing analysis for a lake or reservoir include:

- Area-volume relationships for the surface water body
- Nutrient concentrations in the lake or reservoir
- Lake or reservoir shoreline distance along which groundwater discharge from the development is expected to occur and
- Groundwater concentrations and characteristics as described above for stream and river analysis.

The 7Q10 low flow can be estimated in a number of ways, depending on the flow data available for the stream of interest. If a stream gage for the water body of interest is located near the project and adequate flow data are available an analysis of the flow data can be performed by hand or using software available to estimate the 7Q10. Instructions from the U. S. Geological Survey (USGS, 1972) on how to

[11] Nurnberg, G.K. and B.D. LaZerte. 2004. Modeling the effect of development on internal phosphorus load in nutrient-poor lakes. Water Resources Research. V. 40. W01105. 9 pages.

perform a 7Q10 analysis are available at: http://pubs.usgs.gov/twri/twri4b1/html/pdf.html.

The DFLOW software, available through USEPA at: http://epa.gov/waterscience/dflow/

calculates the 7Q10 flow using data downloaded from the USGS national streamflow database.

Estimates of 7Q10 values for 49 long-term gages in the state of Idaho have been calculated and are available through the Hydro-Climatic Data Network (HCDN) database, a streamflow dataset developed by the USGS, at:

http://www.esf.edu/erfeg/kroll/water_charact.xls

If only partial flow records are available for the water body, such as for parts of a year, an attempt can be made to correlate those flow records with the nearest long-term recording stream gage in the watershed, calculate or obtain a 7Q10 low flow for that long-term gage, and then adjust that 7Q10 based on the observed correlation with the ungauged stream.

A related methodology that may be applicable in selected cases uses a correlation developed between the 7Q10 estimates for the gaging stations mentioned above and, for the same gaging stations, an estimate of the lowest average daily discharge value which is exceeded 80 percent of the time on a monthly basis (Q80). The Q80 for these stations was calculated and is presented in Appendix B of USGS (2001)[12].The correlation between these statistics yields an r^2 of 0.991. Based on this relationship the 7Q10 is predicted to be 71 percent of the lowest monthly Q80 calculated. For ungaged catchments the Q80 can be estimated using the regression relationships reported in the USGS (2001) document or the web-based StreamStats tool, based on these equations, developed by the USGS and available at:

http://water.usgs.gov/osw/streamstats/idaho.html

The resultant Q80 value is then multiplied by 0.71 to obtain the 7Q10 statistic for that stream location.

Recently, the USGS released a report which provides regional regression equations for calculating the 7Q10 statistic at ungaged, unregulated stream locations in Idaho using common basin characteristics (Hortness, 2006)[13].

In some cases, if only isolated flow measurements are available, if it can be demonstrated that those measurements represent likely low flow conditions, they may be acceptable for use.

[12] Hortness, Jon E. and Charles Berenbrock. 2001. Estimating Monthly and Annual Streamflow Statistics at Ungaged Sites in Idaho. United States Geological Survey. Water Resources Investigations Report 01-4093. Boise, Idaho.

[13] Hortness, Jon E. 2006. Estimating Low-Flow Frequency Statistics for Unregulated Streams in Idaho. United States Geological Survey. Scientific Investigations Report 2006-5035.

Once the appropriate data have been obtained the following general equation can be used to calculate the estimated in-stream concentration:

$$C_{stream} = \frac{C_{bkgd}(0.25Q_{stream}) + C_{gw}Q_{gw}}{(0.25Q_{stream}) + Q_{gw}}$$

Equation 2. Stream - Ground Water Mixing Concentration.

where:

C_{stream} = chemical concentration in the stream after mixing with groundwater

C_{bkgd} = background chemical concentration in the stream

C_{gw} = chemical concentration in ground water discharging to the stream after mixing with wastewater

Q_{stream} = 7 day average daily low stream discharge with a recurrence interval of ten years

Q_{gw} = daily ground water discharge to the stream

All chemical concentrations are expressed in mg/liter and discharge in liters/day. The mixed instream chemical concentration is then compared with the target allowable instream concentration.

When estimating the resultant mixing zone concentration for ground water discharge to a lake or reservoir the same equation used for streams can be employed with two substitutions. First, the volume of the lake represented by 10 percent of the surface area of the lake along the length of shoreline where the groundwater discharge is expected to occur is substituted for the discharge of the stream. Second the daily groundwater discharge is extrapolated to a yearly discharge. The resulting equation is:

$$C_{lake\ mixing\ zone} = \frac{C_{bkgd}(Q_{lake}) + C_{gw}Q_{gw}}{(Q_{lake} + Q_{gw})}$$

Equation 3. Reservoir/Lake - Ground Water Mixing Concentration.

where:

$C_{lake\ mixing\ zone}$ = chemical concentration in the lake mixing zone after mixing with groundwater discharged from the project area

C_{bkgd} = background chemical concentration in the lake measured in the mixing zone

C_{gw} = chemical concentration in ground water discharging to the lake after mixing with wastewater

Q_{lake} = lake mixing volume, based on lake bathymetry, measured using a maximum of 10 percent of lake surface area projected along shoreline where ground water discharge from the project occurs

Q_{gw} = yearly ground water discharge to the lake

All chemical concentrations are expressed in mg/liter and discharge in liters/year and volume in liters.

An example calculation of Q_{lake} follows. Assume a lake has a surface area of 10 acres or 435,600 ft^2. Ten percent of this area is 43,560 ft^2. If the project is assumed to discharge along a shoreline length of 1000 ft. the lake volume would be based on an approximate area 1000 ft long by 44 feet wide out into the lake. This area would be multiplied by the average depth of the lake over the 44 foot width (in this example assumed to be 10 feet) to arrive at a Q_{lake} of 1000 x 44 x 10 = 440,000 ft^3 or 1.245E+7 liters.

10.0 Modeling Other Attenuation Processes

Incorporating a more accurate representation of nutrient fate and transport phenomena may allow a project to meet N-P evaluation criteria when a more conservative representation does not. However, additional data collection and model development may be necessary. Justification for performing more complex modeling or using parameter values that deviate from the default values or requirements should be provided. The developer and the N-P professional should assess the costs and benefits associated with a more complex modeling effort. Development of a work plan that describes data collection efforts in support of the model development and the specifics of the modeling proposed should be submitted to DEQ and the Health District for review and discussion.

Consideration of attenuation of nitrogen or phosphorus in the vadose zone or in the saturated zone is one area of more complex modeling that may have potential benefits to the developer. Following is a short discussion of the dominant attenuation processes for these nutrient in the subsurface and the difficulties in representing them in models.

10.1 Denitrification

Attenuation of nitrogen in the vadose and saturated zones, other than by dilution or dispersion, occurs primarily through the process of denitrification. During denitrification, nitrate acts as an electron acceptor during microbial bioremediation of organic carbon sources, yielding nitrous oxide (N_2O) or nitrogen gas (N_2), water, and carbon dioxide. The conditions that are necessary for the complete series of reactions to occur include the following:

- Adequate temperature; while rates of denitrification increase as temperature increases, it has been found that isolates of denitrifying microbial populations were capable of growth and activity at temperatures as low as 39 degrees Fahrenheit (Gamble et al., 1977).[14]

- Reducing conditions; the presence of anoxic conditions is critical to successful denitrification. In aquifers this is indicated by dissolved oxygen concentrations below about 0.5 mg/l. In soils, areas of high moisture content, greater than 60 to 80 percent of saturation, are typically associated with poor aeration, low oxygen content, and measurable rates of denitrification. These areas of high saturation may occur as a result of layering of materials of differing permeability such as found in perched water areas. In the case of soils, the reducing conditions must be present for a sufficient period of time along with the other factors described (adequate temperature and an available carbon source) in order for denitrification to be significant.

  For denitrification to occur in these zones of reduced aeration, it is assumed that the wastewater has encountered a prior aerated zone that would permit the transformation of ammonium nitrogen to nitrate.

- Carbon source; the availability of sufficient, readily mineralizable carbon that can be used as an energy source by microbes is the most critical limitation to denitrification typically identified in field studies associated with on-site wastewater nitrogen impacts (DeSimone and Howes, 1998).[15] This type of organic carbon is often found naturally in soils and aquifers consisting of heterogeneous, layered deposits of fine and coarse-textured materials such as in riparian zones. It can be leached from organic-rich surface soil horizons or it can be provided by the wastewater itself (although much of this carbon is often depleted via transformations in the septic tank and drainfield). A rule of thumb regarding microbial denitrification is that if the nitrate concentration exceeds the organic carbon concentration in ground water the amount of carbon is insufficient to denitrify the nitrate (Korom, 1992).[16]

- Adequate microbial populations; this is usually not a limiting factor in evaluating the potential for denitrification to occur.

  Rates of denitrification in both soils and ground water have been shown to vary substantially, both spatially and temporally. In agricultural soils, it is generally assumed that 15 to 20 percent of applied fertilizer, on average, is lost to denitrification (Myrold, 1991)[17]. Studies of denitrification associated with on-

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[14] Gamble, T.N., M.R. Betlach, and J.M. Tiedje. 1977. Numerically dominant denitrifying bacteria from world soils. Applied Environmental Microbiology. vol. 33. pp. 926-939.

[15] DeSimone, L.A. and B.L. Howes. 1998. Nitrogen transport and transformations in a shallow aquifer receiving wastewater discharge: A mass balance approach. Water Resources Research. vol. 34, no. 2, pp. 271-285.

[16] Korom, S.F. 1992. Natural denitrification in the saturated zone: A review. Water Resources Research. vol. 28, no. 6, pp. 1657-1668.

[17] Myrold, D. 1991. Presented at Nitrogen Transformations in Soils, a Soil Fertility and Water Quality Workshop. Oregon State University. Corvallis, Oregon. March 13-14, 1991.

site wastewater treatment systems have found that losses range from 0 to 35 percent (Ritter and Eastburn, 1985)[18]. In ground water, for coarse-textured alluvial aquifers, daily losses via denitrification in field studies ranged from <1 to 24 percent of initial nitrate concentrations with an average of about 7 percent (Korom, 1992; DeSimone and Howes, 1998).

Incorporating nitrate attenuation through denitrification into an N-P evaluation will require: (1) sufficient site-specific documentation regarding the presence of the conditions described above to provide confidence that denitrification may be operational, (2) a description of how denitrification is implemented in the model that will be used, (3) the associated model input requirements, and (4) justification for the input values chosen.

10.2 Phosphorus Attenuation

Phosphorus attenuation in the vadose and saturated zones occurs primarily through the processes of sorption and mineral precipitation. Phosphorus, typically present as the ortho-phosphate anion, can sorb to a variety of materials and soil surfaces including aluminum, iron and manganese oxides, carbonates, clay surfaces, and soil organic matter. This sorbed phosphorus can be incorporated into the mineral structure of soils or can form precipitates which may lead to the formation of phosphate minerals.

Major factors which control the fate and mobility of phosphorus in the subsurface include pH, oxidation-reduction potential, clay mineral type and amount, the concentrations of associated mineral forming species (such as iron and calcium), and competing anion concentrations (such as sulfate, hydroxide, and carbonate). Typically, in oxidized acid soils, phosphate can be attenuated by iron and aluminum oxides and formation of iron phosphate minerals. This phosphorus can be solubilized and released if anaerobic, reducing conditions occur, such as during spring snowmelt saturation or when anoxic conditions form at the bottom of eutrophic lakes. In alkaline soils the predominant mechanisms for phosphorus attenuation include their incorporation into carbonates and the formation of calcium phosphate minerals.

The modeling of phosphorus fate and transport is complex and is generally not adequately represented by the simple incorporation of soil sorption. Most current modeling efforts attempt to geochemically model the complexation of phosphorus

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[18] Ritter, W.F. and R.P. Eastburn. 1985. Denitrification in on-site wastewater treatment systems. Proceedings of the 5th Northwest On-Site Wastewater Treatment Shortcourse and Equipment Exhibition. September 10-11, 1985. Seattle, Washington. pp. 257-278.

with important soil surfaces such as iron and aluminum oxide coatings and incorporate the formation of phosphorus mineral phases (Parkhurst, et al, 2004).[19]

There is also a growing body of scientific evidence, which suggests that for soil systems phosphorus breakthrough (i.e. increasing phosphorus concentrations in leachate) occurs long before the theoretical phosphorus sorption capacity of the soil is reached. This concept is referred to as the soil *P* change point (McDowell and Sharpley, 2001)[20] or the degree of phosphorus saturation (DPS)(Nair, et al, 2004)[21].

Incorporating phosphorus attenuation through sorption/precipitation into an N-P evaluation will require: (1) sufficient site-specific documentation describing the mechanisms of phosphorus sorption/precipitation operating at the site and information demonstrating confidence that sorption/precipitation is occurring and that sufficient capacity exists or geochemical conditions are such that the liklihood of breakthrough is low, (2) a description of how sorption/precipitation is implemented in the model that will be used, (3) the associated model input requirements, and (4) justification for the input values chosen.

11.0 Modeling Impacts in Fractured Rock Environments

Fractured rock environments present unique challenges to the estimation of impacts from proposed projects involving on-site wastewater systems. Difficulties which may sometimes be encountered include the high degree of variability often seen in aquifer properties and the lack of site-specific information due to the lack of wells or investigations completed in these types of settings. Commonly used ground water fate and transport models (both simple and complex) can often be applied to simulate conditions in fractured rock settings. An important factor which affects this applicability is the scale at which the aquifer behaves or can be treated as an "equivalent porous media". In some settings it may be a local scale (hundreds of feet) while in other settings it may be regional (thousands of feet). Examples of this type of application at both the local and regional scale include modeling completed in the Eastern Snake River Plain aquifer at the Idaho National Laboratory. The decision regarding the appropriateness of using a given model in a fractured rock setting should therefore be made on a site-specific basis in consultation with DEQ staff.

[19] Parkhurst, D.L., K.G. Stollenwerk, and J.A. Colman. 2003. Reactive-transport simulation of phosphorus in the sewage plume at the Massachusetts Military Reservation, Cape Cod, Massachusetts. U.S. Geological Survey. Water Resources Investigation Report 03-4017.

[20] McDowell, R.W. and A.N. Sharpley.2001. Approximating phosphorus release from soils to surface runoff and subsurface drainage. Journal of Environmental Quality. V. 30, pp. 508-520.

[21] Nair, V.D., K.M. Portier, D.A. Graetz, and M.L. Walker. 2004. An environmental threshold for degree of phosphorus saturation in sandy soils. Journal of Environmental Quality. V. 33, pp. 107-113.

12.0 Reporting

A thorough presentation of compiled historical data and the data collected from the project site should be submitted in a written report along with a completed N-P Project Summary and Checklist (Appendix A4). The report should include a professional's interpretation and certification of the findings as well as recommendations for design or the need for further site evaluation. All interpretations need to be well supported by the N-P evaluation data. A suggested outline for an N-P evaluation report follows:

Title: Include a project name

Introduction: list the name of the project, project location, legal description and current land uses; also discuss the intended site use and development design; anticipated wastewater characteristics; geographic, geologic, and hydrologic setting and water well inventory.

1.0 Field Investigation: describe the installation and logging procedures for borings, soil test pits, and monitoring wells; discuss the protocol used in sampling (all media involved), aquifer hydraulic conductivity testing, pathogen fate assessment, and contaminant fate and transport modeling for ground water and surface water; include documentation supporting assumptions made during model development.

2.0 Results: Discuss soil conditions; ground water elevation and flow characteristics; background water quality; hydraulic conductivity; nutrient-pathogen fate issues; model results; model uncertainty.

The N-P evaluation report should include a discussion about the accuracy of the flow component and about any other parameters (flow or contaminant transport) that are particularly sensitive. Several model runs that include a range of input parameters may be warranted when the uncertainty about the value of key parameters is high. Modeling predictions should err on the side of conservatism (i.e., "worst-case" scenarios need to be taken into account in the development design).

When presenting the results of numerical models a figure showing contours of predicted concentrations should be supplemented with a narrative indicating what the specific predicted concentrations are at the compliance points.

3.0 Conclusions: summarize the key elements of the evaluation.

4.0 Recommendations: provide recommendations for development layout; on-site wastewater treatment system design; water supply and well construction; and the need for further evaluation activities.

The presentation of recommendations on the part of the N-P professional constitutes certification that: (1) the data adequately support the recommendations and, (2) that interpretations based on the data are accurate and represent sound, unbiased professional judgment.

13.0 Monitoring

Currently, neither the PHDs nor DEQ requires post-development ground water monitoring except in instances involving LSAS or CS (see IDAPA 58.01.03.013; http://www2.state.id.us/adm/adminrules/rules/IDAPA58/58INDEX.HTM). However, periodic sample collection from ground water monitoring wells installed as part of the N-P evaluation is recommended.

It is recommended that samples be collected at least twice per year (usually during times that represent low water table and high water table conditions) and analyzed for nitrate+nitrite, TKN, chloride, sodium, and coliform density (total and fecal coliform and fecal streptococcus) bacteria. Anomalous or unexpected monitoring results should be discussed with the health district and DEQ in order to formulate an appropriate remedy.

APPENDICES

A1 Additional Sources of Information

This section provides a listing of some information sources which may be appropriate for use in deriving aquifer property information for specific aquifers around the state. It is not intended to be an exhaustive compilation of data sources. Other sources of information include projects performed at DEQ or under contract to DEQ. An example of the former is shown in Figure A1-1. This figure illustrates zones of horizontal hydraulic conductivity values for the uppermost portion of the Treasure Valley aquifer. This data was adapted from the steady-state calibrated ground water flow model of the Treasure Valley developed by IDWR and IWRRI (Petrich, 2004). An example of the latter is Source Area Delineation Report, Porteneuf Valley-Gem Valley (2002), prepared for DEQ by Washington Group International. This is a Source Water Assessment (SWA) delineation document developed for specific public water systems for DEQ.

Treasure Valley Aquifer

Petrich, Christian. 2004. Simulation of ground water flow in the lower Boise River basin. Idaho Water Resources Research Institute and Idaho Department of Water Resources. IWRRI-2004-02. February 2004.

Additional reports from the IWRRI investigations are available at http://www.idwr.idaho.gov/hydrologic/projects/tvhp-revised/

Eastern Snake River Plain Aquifer

Lindholm, G.F. 1996. Summary of the Snake River Plain regional aquifer-system analysis in Idaho and eastern Oregon. U.S. Geological Survey Professional Paper 1408-A.

Garabedian, S.P. 1992. Hydrology and digital simulation of the regional aquifer-system, Eastern Snake River Plain, Idaho. U.S. Geological Survey Professional Paper 1408-F.

Reports related to recent computer modeling of the Eastern Snake River Plain by IWRRI can be found at http://www.idwr.idaho.gov/hydrologic/projects/espa/

Twin Falls Area Aquifer

Moffat, R.L. and M.L. Jones. 1984. Availability and chemistry of ground water on the Bruneau Plateau and adjacent Easter Plain in Twin Falls County, south-central Idaho. U.S. Geological Survey. Water Resources Investigation Report 84-4065.

Cosgrove, D.M., G. S.Johnson, C. E. Brockway, and C.W. Robison. 1997. Geohydrology and development of a steady state ground-water model for the Twin Falls, Idaho area. Idaho Water Resources Research Institute. Research Technical Completion Report.

Rathdrum Prairie Aquifer

As part of the Spokane Valley-Rathdrum Prairie Hydrologic Project currently being conducted by IDWR and the USGS a bibliography of studies completed relating to the aquifer has been compiled. This compilation is available at: http://wa.water.usgs.gov/projects/svrp/publications.htm

Long Valley

Otto, B.R., A. Wylie, and D. Ralston. 2005. Preliminary hydrogeology of the Cascade area, Valley County, Idaho. Idaho Water Resources Research Institute. Technical Report 200425. Prepared for the Idaho Department of Environmental Quality.

Big Wood River Valley

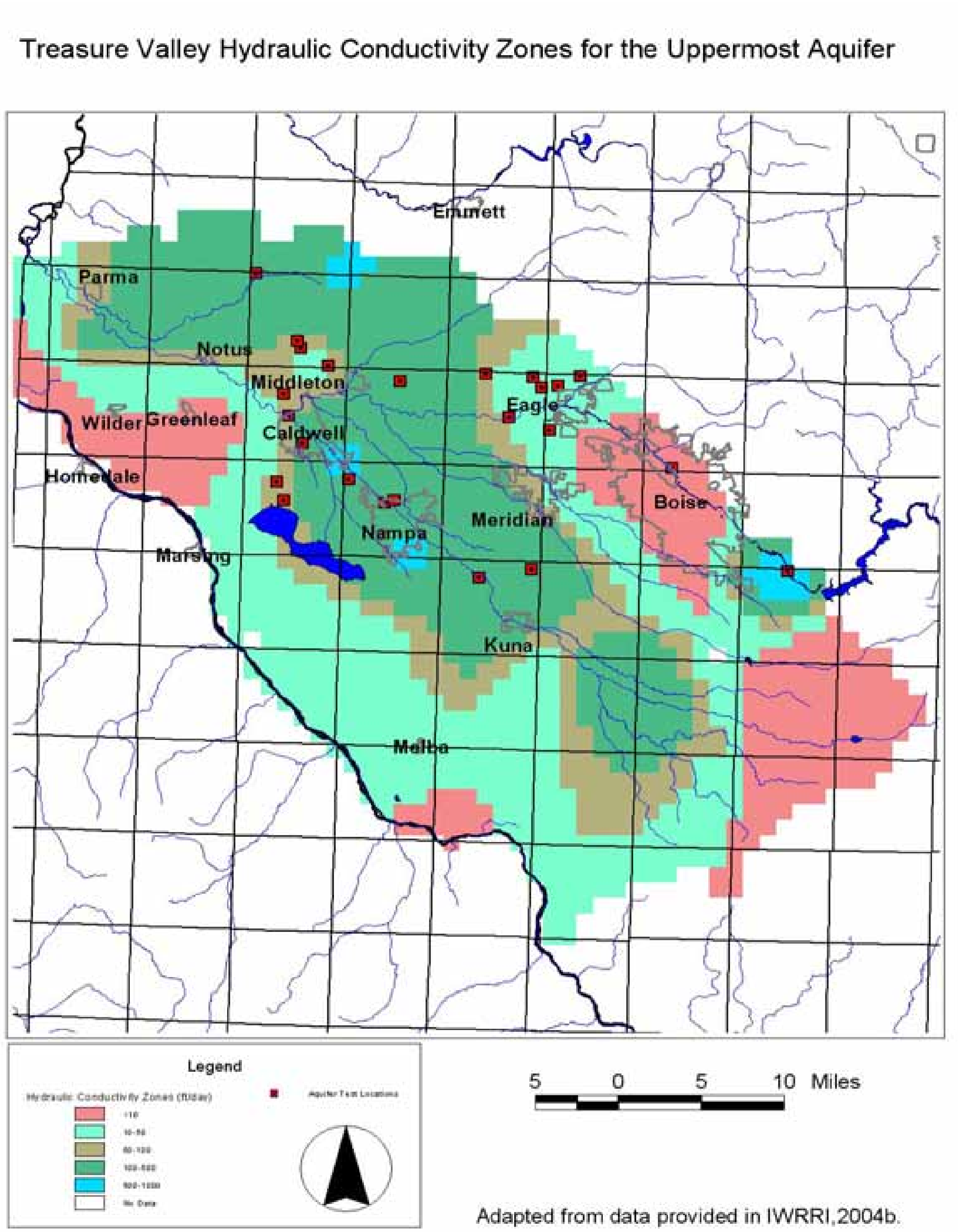
Brockway, C.E. and M.A. Kahlown. 1994. Hydrologic evaluation of the Big Wood River and Silver Creek watersheds. Phase 1. Final report. Submitted to The Nature Conservancy of Idaho. U of I. IWRRI. Kimberley Research and Extension Center.

Wetzstein, A.B., C.W. Robison, and C.E. Brockway. 2000. Hydrologic evaluation of the Big Wood River and Silver Creek watersheds. Phase 2. Research Technical Completion report. Submitted to The Nature Conservancy of Idaho. U of I. IWRRI. Kimberley Research and Extension Center.

Grande Ronde

Lum II, W.E., J.L. Smoot, and D.R. Ralston. 1990. Geohydrology and numerical model analysis of ground-water flow in the Pullman-Moscow area, Washington and Idaho. U.S. Geological Survey. Water Resources Investigation Report 89-4103.

Stevens, Gary R. 1994. Evaluation of the Groundwater Resources Within the Lewiston Basin. M.S. Thesis. University of Idaho. 235 pages.



Appendix Figure 1 Distribution of Treasure Valley uppermost aquifer's estimated Hydraulic Conductivity. (IDWR, 2004).

A2 Internet Resources of Interest

American Society of Civil Engineers seepage/ground water modeling links

http://emrl.byu.edu/gicac/gw.html

Bacterial source tracking web pages

http://www.bsi.vt.edu/biol_4684/BST/BST.html

Central District Health Department Environmental Health Division

http://www.phd4.state.id.us/EnvironmentalHealth/

Environmental Modeling Systems, Inc. (GMS)

http://www.ems-i.com/

Idaho State Department of Agriculture water quality information

http://www.agri.state.id.us/agresource/gw/Water%20Resources%20TOC.htm

Idaho Department of Environmental Quality home page

http://www.deq.idaho.gov/

Idaho Department of Environmental Quality rules

http://www.deq.idaho.gov/adm/adminrules/rules/IDAPA58/58INDEX.HTM

Idaho Department of Water Resources Snake River Resources Review study area

http://www.idwr.state.id.us/usbr/

Idaho Department of Water Resources water information

http://www.idwr.idaho.gov/hydrologicl/

Idaho Geological Survey home page

http://www.idahogeology.org/

Idaho Technical Guidance Manual for Individual and Subsurface Sewage Disposal Systems

http://www2.state.id.us/deq/waste/tgm_sewage.htm

Idaho Water Update (outreach newsletter)

http://www.idahowaterupdate.com/

Isogeochem stable isotope resources

http://geology.uvm.edu/geowww/isogeochem.html

Leopold Center for Sustainable Agriculture at Iowa State University

http://www.leopold.iastate.edu/

Natural Resources Conservation Service science & technology

http://www.info.usda.gov/nrcs/SandT/

North Carolina on-site wastewater non-point source pollution program

http://www.deh.enr.state.nc.us/oww/nonpointsource/NPSseptic/npsseptic.htm

Oregon State University Hillslope and Watershed Hydrology Group

http://www.cof.orst.edu/cof/fe/watershd/h20fram5.html

State of Idaho access to state information

http://www.accessidaho.org/index.html

U.S. Department of Agriculture office information locator

http://offices.usda.gov/scripts/ndISAPI.dll/oip_public/USA_map

U.S. Department of Agriculture, Agricultural Research Service, Salinity Laboratory

http://www.ussl.ars.usda.gov/index000.htm

U.S. Environmental Protection Agency Center for Subsurface Modeling Support

http://www.epa.gov/ada/csmos.html

U.S. Environmental Protection Agency Office of Ground Water and Drinking Water

http://www.epa.gov/safewater/dwhealth.html

U.S. Geological Survey ground water information pages

http://water.usgs.gov/ogw/

U.S. Geological Survey Idaho District Office

http://idaho.usgs.gov/

U.S. Geological Survey national mapping information

http://mapping.usgs.gov/

A3 Published Literature of Interest

Aquifer Hydraulic Testing

Alyamani, M.S. and Z. Sen. 1993. Determination of hydraulic conductivity from complete grain-size distribution curves. Ground Water. v. 31, no. 4, pp. 551-555.

American Society of Testing and Materials. 1999. Standard Test Method for Determining Specific Capacity and Estimating Transmissivity at the Control Well. Standard D-5472-93 (Reapproved 1999).

California Environmental Protection Agency. 1995. Aquifer Testing for Hydrogeologic Characterization. Guidance Manual for Ground Water Investigations. July 1995.

http://www.dtsc.ca.gov/sitecleanup/ground_water_investigations.html

Kruseman, G.P. and N.A. de Ridder. 1992. Analysis and Evaluation of Pumping Test Data. The Netherlands: International Institute for Land Reclamation and Improvement, Publication 47.

U.S. Environmental Protection Agency. 1993. Ground Water Issue, Suggested operating procedures for aquifer pumping tests. EPA/540/A-93/503, Robert S. Kerr Environmental Research Laboratory, 23 p.

Bacteria and Viruses

Allen, M.J. and S.M. Morrison. 1973. Bacterial movement through fractured bedrock. Ground Water. v. 11, no. 2, pp. 6-10.

Brown, K.W., H.W. Wolf, K.C. Donnelly, and J.F. Slowey. 1979. The movement of fecal coliforms and coliphages below septic lines. J. Environ. Qual. v. 8, no. 1, pp. 121-125.

Drewry, W.A. and R. Eliassen. 1968. Virus movement in ground water. J. Water Pollution Control Federation. v. 40, no. 8, pp. 257-271.

Udoyara, S.T. and S. Mostaghimi. 1991. Model for predicting virus movement through soils. Ground Water. v. 29, no. 2, pp. 251-259.

Vaughn, J.M., E.F. Landry, and Z.T. McHarrell. 1983. Entrainment of viruses from septic tank leach fields through a shallow, sandy soil aquifer. Applied and Env. Microbiology, v. 45, no. 5, pp. 1474-1480.

Dispersion and Dispersivity

Al-Suwaiyan, Mohammad S. July-August 1996. Discussion on “Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale” by Xu and Eckstein, Discussion Ground Water, V. 34, No.4, November-December 1995.

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A4 Example Form

General Project Information	
Project/Subdivision name:	
Legal Description:	T R Section Qtr Qtr Qtr . T R Section Qtr Qtr Qtr . T R Section Qtr Qtr Qtr .
Date:	
Development area (acres):	
Number of lots:	
Range of lot sizes (acres):	
County:	
N-P Evaluation performed by:	

Nitrate Mass Balance Evaluation (minimum information) **(check elements included in report)**		
Required Element	Included	Notes:
Well driller reports within ½ mile radius	☐	
Project map	☐	
Ground water depth and flow information	☐	
General soil and surface geologic information	☐	
Soil descriptions from on-site test pits/borings	☐	
Ground water quality information for vicinity	☐	
Mass-balance spreadsheet results	☐	

Analytical Model or Numerical Flow & Transport Model (indicate information used/included in report)			
Parameter	N-P Default	Value Used	Comments/Justification
Monitoring wells installed	3 (minimum)		
Number of water quality samples collected	3 (minimum)		
Type of flow and transport model used:	site-specific		
Grid spacing	site-specific		
Aquifer top elevation (ft)	site-specific		
Aquifer bottom elevation (ft)	site-specific		
Hydraulic conductivity (ft/d)	site-specific		
Ground water gradient	site-specific		
Effective porosity: ▪ medium-sized sediment ▪ fractured rock	 0.20 to 0.35 ≤0.20		
Dispersivity: ▪ α_L(ft) ▪ α_{TH}(ft) ▪ α_{TV}(ft)	See Section 8, Equation 1, Table 8-1		
Wastewater flow per drainfield (gal/day)	300		
Nitrate concentration per drainfield (mg/l as N)	50		
Phosphorus concentration per drainfield (mg/l)	12		
Nitrate source introduction: ▪ injection wells ▪ recharge from surface	 upper 15 ft of aquifer recharge area sized to match drainfields		
Complex Models (optional)			

Analytical Model or Numerical Flow & Transport Model (indicate information used/included in report)			
Parameter	N-P Default	Value Used	Comments/Justification
Provide narrative description of additional modeling parameters for: ▪ models considering vadose zone or saturated zone attenuation ▪ areally-distributed recharge from irrigation and precipitation ▪ phosphorus modeling			